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Forthcoming Events.

FEBRUARY 5.

British Foundrymen's Association (Manchester Branch).—"Coke for Foundry Use," by E. L. Rhead, F.I.C., F.C.S.

FEBRUARY 19.

British Foundrymen's Association (Sheffield Branch).—"The Production of Malleable Cast Iron," by J. Matthews.

FEBRUARY 26.

British Foundrymen's Association (Birmingham Branch) "Practical Demonstration of the Preparation of Specimens for Metallography," by G. Hailstone.

NOTES AND COMMENTS.

Copper-Aluminium-Manganese Alloys.

On another page we present an abstract of the Ninth Report to the Alloys Research Committee of the Institution of Mechanical Engineers, which deals with the properties of some alloys of copper, aluminium, and manganese. Unfortunately, owing to the length of the Report, it is impossible to reproduce more than an abstract; but it is well worth a detailed study, for some of the points brought out by the authors, Dr. W. Rosenhain and Mr. F. C. A. H. Lantsberry, appear to indicate a very important future for some of these alloys. As regards the alloys consisting chiefly of aluminium, these did not appear so promising as some of the others, but an interesting feature of the results obtained with these alloys is the determination of the very great extent to which the properties of the metal depend, in the case of castings, on the temperature at which the metal is poured into the moulds. The possible extent to which manganese can be usefully added to alloys consisting principally of aluminium was found to be limited, and the study of ternary alloys was confined to the range containing less than 4 per cent. of either copper or manganese. But two alloys, viz., those containing 2 per cent. of copper and 2 per cent. of manganese, and 3 per cent. of copper and 1 per cent. of manganese, respectively, gave very interesting results, for it was found that while a chill-casting poured at a mean temperature of 680 degrees C. gave a tensile strength of 11.6 tons per square inch, with an elongation of 8 per cent. on 2 in., the same metal poured into a similar mould at a mean temperature of 750 degrees C. gave a tensile strength of less than 6 tons per square inch, and an elongation of only 2 per cent.—both castings being apparently quite sound.

As regards the alloys rich in copper, perhaps the most interesting discovery was that concerning their resistance to abrasion. This quality, if borne out by practical experience, should render these alloys of considerable value, for they presented a resistance to abrasion which places them in this respect considerably above ordinary tool steel. Under loads which would immediately indent and destroy any ordinary bearing metal, rings of these alloys have been run for a large number of revolutions with only an inappreciable amount of abrasion. The alloys in question contained from 7 to 10 per cent. aluminium and 1½ to 5 per cent. manganese. This resistance to abrasion, combined with the fact that they machine quite readily, should open up an important field of application. With the introduction of these alloys into foundry work—for they are bound to come into the foundry if the results of the experiments are borne out in practice—we shall doubtless see many founders in trouble, through not understanding the new metals. There is sufficient trouble already experienced by the uninitiated when handling alloys containing aluminium to justify this belief, though experience and study will overcome all difficulties.

—B

Cast Iron for Superheated Steam.

It is no uncommon thing to find makers of wrought-steel pipes referring to the cast-iron pipe trade as though it were practically extinct for all purposes where strength is needed, and it is still more usual to hear cast iron condemned for use where steam pressures have to be withstood. Cast-iron fittings in use with superheated steam have at various times failed, and steel castings have been substituted as stronger articles, but it has not yet been proved that cast iron is the inferior metal for the work, or that steel castings offer any material advantage. The idea that cast iron deteriorates under the conditions of use with superheated steam probably arises from the knowledge of its property of "growing" under maintained high temperatures, but there appears to be little conclusive evidence that this feature operates materially to the detriment of the iron when employed for the purposes stated. We publish elsewhere in this issue abstracts of three papers treating with the loss of strength of cast iron as the effect of being exposed to superheated steam, but in each case such evidence as is offered can only be classed as very inconclusive. The third paper on the subject comes very near the mark in suggesting that the fault, in cases where iron has failed, has not been with cast iron as such, but rather in the quality of cast iron used. Steel castings, too, have been known to fail with superheated steam, and when a comparison between them is made it is not fair to take an iron casting of an unsuitable iron. As pointed out by the author of the third paper, a thoroughly sound steel casting is able to withstand highly superheated steam, and while superheated steam does not of itself initiate defects, if there is an initial defect, superheated steam is much more active in bringing out the objectionable features of that defect. Some material better than the ordinary steel casting is desirable for high-temperature work, and such a material is found in high-grade cast iron, or gun iron, as it is termed. Since, then, satisfaction can be got from a fitting of high-grade cast iron, the trouble and uncertainty which is associated with steel need not be courted by the founder, though it may be difficult to convince some engineers that steel is not essentially the better. At the same time, it must be remembered that under certain conditions the elasticity of steel is a considerable advantage; conditions, then, must govern the decision as to which material to employ.

Ferro-Silicon and its Dangers.

On another page we summarise the report recently issued by the Local Government Board on the nature and uses of ferro-silicon. It may be questioned whether the subject warranted a report running to 114 pages, though it cannot be denied that a mass of valuable information is given. But all practical iron and steel makers and foundrymen know perfectly well that ordinary blast-furnace ferro-silicon is as safe as regards poisonous emanations as ordinary pig-iron, and to the popular mind a more inert substance than pig-iron could hardly be selected for comparison. The time spent in investigating blast-furnace ferro-silicon may therefore be regarded as wasted from the immediate point of view of the enquiry, though in other directions important points have been brought out.

The use of silicon has, of recent years, come very much to the fore in metallurgical circles; its functions in the manufacture of, and its effects on the physical properties of, steel, may be classified as follows:—

(*a.*) Silicon in being oxidised in the furnace or converter acts as a metallurgical fuel.

(*b.*) Owing to the heat produced it will cause molten steel to remain fluid for a long time, and so enable thin and intricate castings to be made.

(*c.*) It acts as a reducing agent or otherwise to prevent the formation of blowholes in castings.

(*d.*) It is used as an admixture in steel to produce certain important physical properties in the highest degree.

We are not disposed to quarrel with the proposed precautionary measures in connection with the storage and transport of the material, but is cannot be denied that the fact that no electrically produced ferro-silicon is made in this country adds gravity to the question in view of the dangers of transporting it, and to the steel maker the matter is an important one. But it is questionable whether it is of very great importance to the foundryman whether or not the supply of high-grade ferro-silicon is restricted; there are substitutes that have already taken its place in many instances, and here at least the immediate solution to the question lies, so far as it concerns the foundryman.

Powdered Fuel.

Our contemporary "Castings," after soliciting the opinion of a number of people who have experimented with the use of powdered fuel, states that the general opinion is that powdered fuel is not suitable for melting brass. If the brass is melted in a reverberatory furnace, it is contended, the ashes falling on the surface of the bath tend to contaminate it, and the sulphur in the fuel would also injure the metal. Molten brass has a very strong affinity for gases, and it would be necessary to use a deep slag to prevent the excessive absorption of this. This blanket of slag would retard the passage of heat and make the melting slow. If crucibles were used it would be difficult to construct a furnace which would utilise the powdered fuel properly, as this has to be completely burned in a separate combustion chamber. Should any of the powdered fuel come in contact with relatively cold crucibles it would stick to them and not be properly burned.

No one has apparently yet designed a furnace for burning powdered fuel in which crucibles can be successfully used, but in view of the advances that have been made in furnaces of all descriptions for burning powdered fuel such as coal dust, etc., it would be unwise to suggest that this fuel cannot be successfully applied for crucible work. For open-hearth furnace work it appears to be well adapted, and allows of comparatively high temperatures being obtained, owing to the complete combustion of the fuel in close proximity to the metal. As regards the ashes falling on the metal and contaminating it, this contamination should be negligible if the bath of metal is properly protected by charcoal, etc., and if it is not protected the fumes from a gas furnace would be equally liable to contaminate it. In respect to the deep slag necessary for the protection of the metal against the gases evolved, we would suggest that this is no more important a feature with powdered fuel than with gas-firing in a reverberatory furnace, and in most classes of furnace a slag covering of some depth is obtained. There are, of course, a number of difficulties that prevent the ready adoption of powdered fuel for brass-work, and where trouble has been experienced with it perhaps the safest plan is to revert to a fuel that is better understood. But the difficulties associated with the use of powdered fuels ought not to prove insurmountable.

Points in Working Cupola Furnaces.*

The temperatures to which the furnace lining is exposed range from 1,200 to 1,400 C. in the case of crucible and reverberatory furnaces for brass; 1,500 to 1,600 C. in cupola and reverberatory furnaces for cast iron; 1,650 to 1,700 C. in crucible furnaces for mild steel, and 1,700 to 1,800 C. in open-hearth furnaces for mild steel. Consequently, all parts of the furnace that will come in contact with molten iron must be lined with best refractory material, whereas the upper part of the shaft may be lined with semi-fireproof bricks, and the top with ordinary well-burned brick.

With a properly constructed furnace it is possible to obtain a large output without top tuyeres, provided an efficient blast is available and the charge is mixed in the right proportions. It is advisable to use rather more coke than is theoretically necessary, in order to allow for differences in the ash content and calorific power. Little value attaches to the theory that a saving can be effected in the coke consumption by reducing the carbon dioxide in the zone of fusion to carbon monoxide, and thus reducing the inherent 8,080 calories in the former to the 2,473 calories of the latter, the idea being that the gas can be re-oxidised again higher up, and that the molten iron trickles down through the carbon monoxide zone chemically unaltered. In practice, these conditions are difficult to maintain; and indeed, if the coke in the charge is burned to carbon dioxide and the latter parts with its heat to the iron in the charge, so that the effluent gases are cool, then all the available heat will have been extracted, and no elaborate precautions are required. With a properly distributed blast and duly proportioned charge, the maximum results can be obtained with 6 per cent. of coke (referred to the weight of iron in the charge). The carbon dioxide is cooled down so quickly by the iron that there is no risk of the top layers of coke being burned to waste.

The assumption that an abundance of carbon monoxide reduces the amount of waste is not borne out by practical experience. Beckert found that in the Herbertz furnace the whole of the coke is consumed to carbon dioxide, the effluent gases being free from any trace of the monoxide and rich in free oxygen. Consequently, the molten iron has to trickle down through an oxidising atmosphere, in spite of which the loss of iron is only about 2½ per cent. Trial smeltings with the Herbertz furnace have shown a coke consumption of 9.9 per cent., whilst in the Greiner and Erpf furnace it was only 6 per cent., and the same in the author's trials with an ordinary furnace with bottom tuyeres only, and uniformly distributed blast.

Amongst other conclusions, the author states that simplicity of working is essential to success, coupled with an ample air blast and a large tuyere area in comparison with the sectional area of the furnace. The loss of iron depends on the composition of the charge, rather than on the method of smelting, though hot smelting is necessary to ensure the chemical combination of the materials. A collecting hearth ensures uniformity of the metal from a charge. The blast air should be warmed to 50 to 100 C., because it keeps the slag more fluid and prevents it from choking up the tuyeres or hanging in the furnace. The distance from the charging platform to the charging mouth should be small, the difference in level, however, being not less than about 40 in. This height, whilst not overtaxing the men when throwing in the charge, is sufficient to protect their faces from the escaping gases. Wet coke should not be used for heating up the furnace or in the charge, or the furnace will be robbed of heat and the iron will not be sufficiently fluid; the same applies, to an even greater extent, to the moisture in the air blast. Hot smelting helps to prevent the occlusion of gases—especially hydrogen and nitrogen—in the molten iron, and thus furnishes a more compact metal, the condition of the resulting castings being still further improved by pouring at a medium temperature.

* A. Messerschmidt in "Stahl und Eisen."

Pig-Iron Steel.

By J. F. P. L.

The articles which have recently appeared in this journal regarding mixtures of iron and steel have doubtless created a good deal of interest in ironfounding circles, and it is to be hoped have also caused some reflection. The writer has had some experience of ironfounding in the leading industrial countries of the world, and he has never found any substantial evidence (in the direction of practical results) that mixtures of iron and steel in any form have led either to improved or in the long run to more economical castings. The point ought to be kept clearly before your readers that what is aimed at by these mixtures is cheapness, not higher quality of the castings made. No mixture of steel and iron can hold its own in the ironfoundry for a moment against a mixture of really strong, grey, low-carbon, low-silicon pig-irons, or pig-irons and scrap, It is the consideration of the somewhat considerable cost of such irons smelted direct from the ore that has led to the introduction of the new mixtures and to the steel-briquetting plants. The Germans are highly scientific, and excel in some important branches of manufacture, but the leading Teutonic instinct is cheapness, not quality. It is hard to find anything exceptionally bad being turned out of an up-to-date German ironfoundry, much harder than in England, but it is difficult to find anything exceptionally good. The mixture of iron and steel, where a cast-iron product is ostensibly looked for, transgresses important physical laws, and in some form or at some time or other the foundry mixing them will have to pay for this transgression.

The competent ironfounder who has during many laborious years brought all his intelligence to bear on his iron mixtures for different purposes, and who has studied the phenomena of melting iron, molten iron, and of cooling iron, has certainly established several fundamental laws by which he regulates his operations. Whenever good, strong, dense, close and regular-grained castings are required, he will insist: (1) on the maximum variation between the carbon and silicon percentage of each constituent of his mixture being kept at the lowest possible figure; (2) on his mixture having as nearly as possible one melting point; and (3) on the different irons having as nearly as possible the same specific density.

The latter two points may depend largely on the first, but may, for physical reasons neglected in theory or for undiscovered chemical reasons, be quite independent of it. The above mentioned three points

are the golden rules for producing high-grade castings in iron. Every one of them is transgressed very flagrantly directly steel, steel offal or steel briquettes are introduced into the mixture.

Let us be fair to this pig-iron steel and grant at once the advantages it may give, which are cheapness and higher tensile and transverse strength. Owing to the difficulty and uncertainty of treatment it is quite likely it will not often give the latter, but certainly it may. But against this what disadvantages are involved? The writer has always considered that to the same extent as steel is introduced into the ironfounder's mixture, so will the characteristic difficulties of the steel founder be introduced into his practice. He will get the viscosity of steel, the contraction of steel, and the gasiness of steel, and he does not want any of these. The first will increase the difficulty of feeding and hence of getting a tight casting, the second will increase the tension stresses in his casting between the red-hot solid and cold state, and the third will bring him blowholes. What good is an increased tensile strength, especially in castings, such as valves and cylinders, where tensile strength is not the great desideratum, if it is at the expense of the all-round quality of the casting which should be of regular structure and unimpaired density throughout?

Also we must consider the all-important question of hardness, which is often an essential feature of high-grade grey iron castings. The result of iron and steel mixtures in castings of fair section is softness, and castings of heavy section are often rotten-soft. In this direction the reduced carbon and silicon in the mixture brought about by the steel does not act in the way desired. It is often found that large cylinders made of mixtures of pig-iron (worked out with the highest scientific regard to a theoretical analysis), wrought iron and steel, test bars cast from portions of which show extremely high tensile strength, when subjected to an ordinary superheated steam pressure very soon, to borrow the expression of the somewhat coarse young gentleman in "The Vicar of Wakefield" come "all of a muck sweat." If these pig-iron-steel products are offered as a "quality" article the offer should be suscepted. They are certainly offered as a cheap subsitute for high-grade English cold-blast and hot-blast low-carbon smeltings. Such products as the best of these are not turned out by German high-furnace men, who still have a great deal to learn.

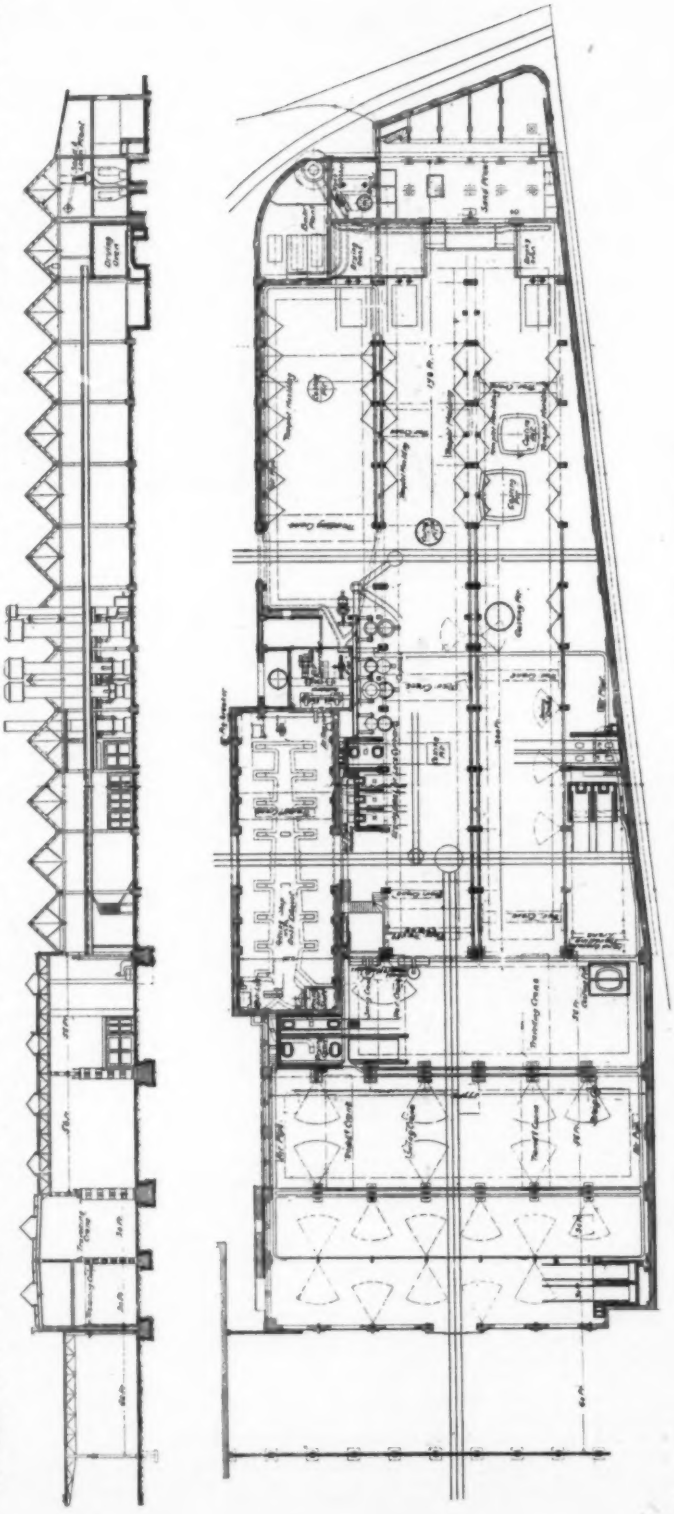


FIG. 1.—THE LARGE FOUNDRY AT THE SULZER WORKS, WINTERTHUR.

The Sulzer Foundry, Winterthur.*

In view of the comparative poverty of Switzerland in coal and iron ore, and the small production of pig-iron and steel, it is remarkable that the iron industry, especially in the machinery branch, should have attained such a high state of development as to have acquired world-wide renown. Among the pioneers of this industry, a high position is occupied by the Sulzer family, two members of which—the brothers Johann Jakob and Salomon—established a small foundry and locksmith's business at Winterthur, in 1834—a business which has now attained very considerable dimensions, and finds employment for about 5,000 hands.

At present the foundry plant at the Winterthur Works—there is also a foundry, with an output of 20,000 tons per annum, at Ludwigshafen—is divided into four independent departments; the heavy castings, metal foundry, small castings, and radiator foundry departments, all connected with the railway, and traversed by a network of standard and narrow gauge tracks, to facilitate the handling of the material from the raw to the finished state. The large castings department (Figs. 1 and 2), in which heavy sand and loam castings are chiefly produced, occupies an area of about 7,500 square yards, and is equipped with eighteen 5 to 25-ton electric travelling cranes, one 2-ton hydraulic hoist, a pneumatic hoist of similar capacity, two 2-ton hand-operated travelling cranes, one 2-ton electric swing crane, twenty-one 1 to 3-ton hand-operated wall swing cranes, and two 2-ton hand-operated velocipede cranes.

At the south end of the casting shop the sand and loam are dried, mixed, ground and sifted, the loam being treated in kneading machines, and the finished materials are conveyed to the various parts of the casting shop by suitable appliances. The moulding shop contains five pits, up to 14 ft. in depth, and up to 20 ft. diameter, another pit 25 ft. deep being situated in another part of the foundry. The moulding sleekers are arranged along the rows of pillars, to obtain a secure mounting for the spindles. Toothed pinions are moulded on special machines, with special milling attachments for the tooth pattern. The five fore-hearth cupola furnaces are ranged along one side, to facilitate the distribution of the molten metal to all parts of the shop. The furnaces have a capacity of 5 to 9 tons per hour, and the fore-hearths will hold charges of 8 to 10 tons. The blast, at a pressure of 22 to 26 in. water-gauge, is furnished by fans housed in the rear of the furnaces. A hydraulic hoist raises the tubs up to the charging platform. A compressor in the same house as the fans supplies air at 90 lbs. pressure for the pneumatic mould rammers (Fig. 3) and cleaners. Another fan supplies air to the portable mould driers.

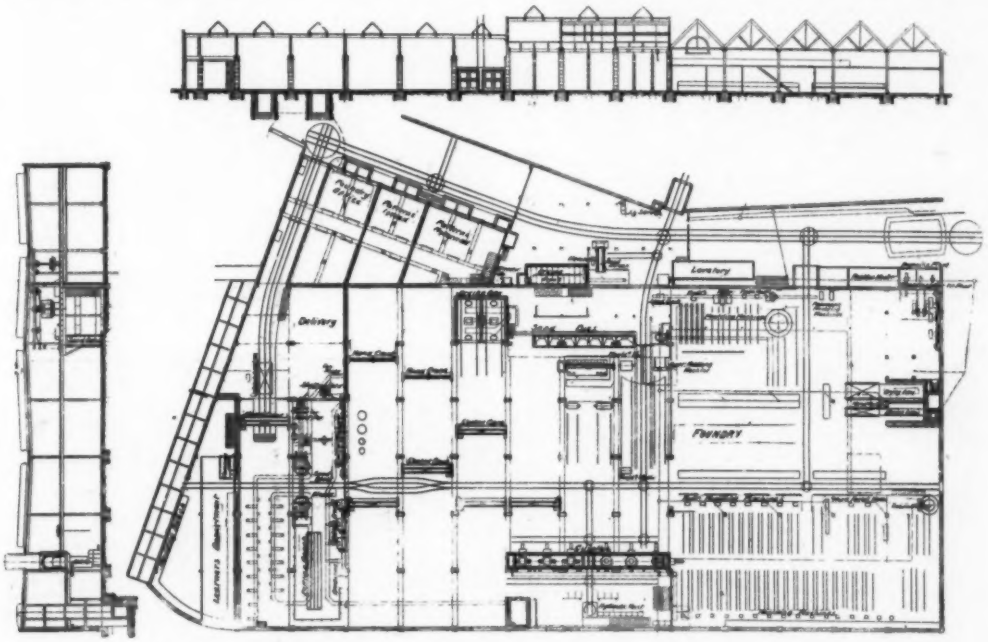


FIG. 6.—THE SMALL CASTINGS FOUNDRY AT THE SULZER WORKS.

Behind the cupola furnaces is the fettling shop, a chief feature of which is the device (Fig. 10) for exhausting the dust by fans through a number of openings in the floor, leading to a common main from which the deposited sand is removed by a hydraulic hoist. Ventilation is supplied by fans, the air being warmed during the winter months.

The plant for small and medium castings (Figs. 5 and 6) occupies an area of about 6,500 square yards, and is divided into three parts, one of which houses the moulding machines. These are of a variety of types, in view of the divergent character of the cast-

* Abstract from an article in "Stahl und Eisen."

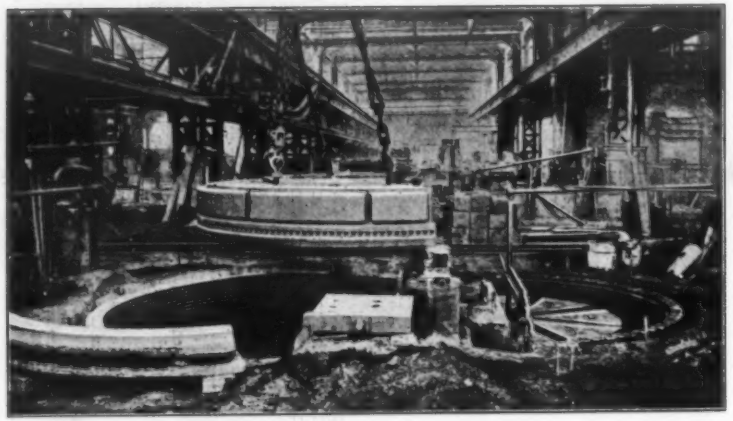


FIG. 2.—VIEW IN THE LARGE FOUNDRY.

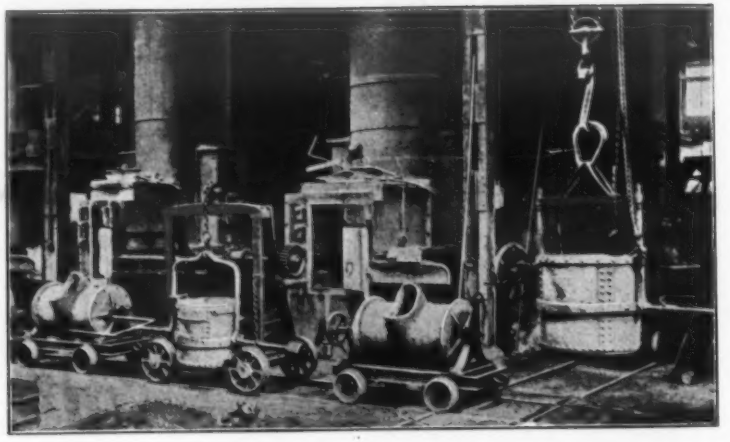


FIG. 4.—LADLE TRUCKS IN THE SMALL CASTINGS FOUNDRY.

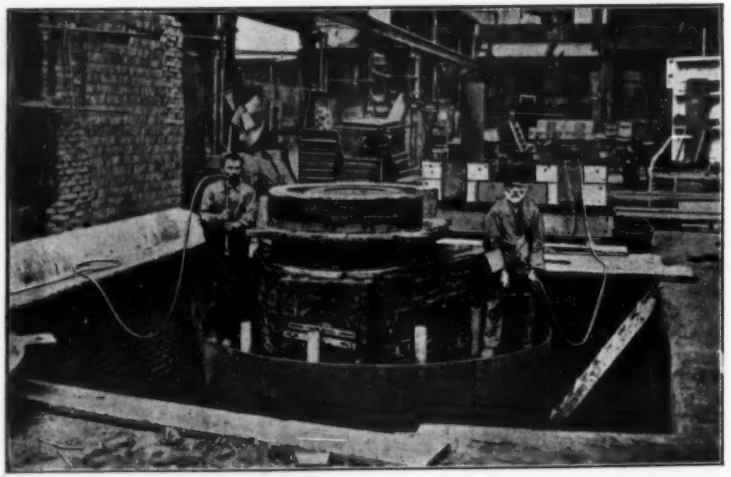


FIG. 3.—PNEUMATIC MOULD RAMMING IN THE LARGE FOUNDRY.

FIG. 5.—VIEW IN THE SMALL CASTINGS FOUNDRY.

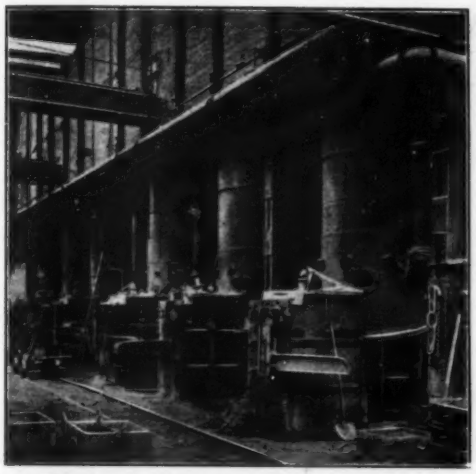


FIG. 7.—CUPOLA FURNACES IN THE SMALL CASTINGS FOUNDRY; SULZER WORKS.

fettling shop has two long benches, a fettling drum, two sand blasts, and emery and grinding machines. The dust is removed, as in the other fettling shop described. On the east of this building are the packing house and pattern store, the latter being set out in such a manner as to ensure control over the issue and return of the patterns.

The metal foundry (Fig. 8) has three upper storeys and two in the basement, and is of recent erection. The casting shop is on the top floor, with the melting, moulding, core and fettling shops, whilst the sand is treated on the first floor. There are four Piat-Baumann melting furnaces, holding 4 to 6 cwts. each, and two Fletcher furnaces (Fig. 9). The repairing shop for the whole foundry and the pattern-making shop are on the ground floor: and the pattern store, general store, lavatories and change rooms are in the basement. The transfer of material from one storey to another is effected by means of a 2½-ton electric hoist.

The radiator foundry (Fig. 11) is built of brick, ferro-concrete and iron, and is well lighted and ventilated, six fans being provided. One end of the first floor is occupied by the sand plant, the drying ovens being underneath. Three cupola furnaces, with

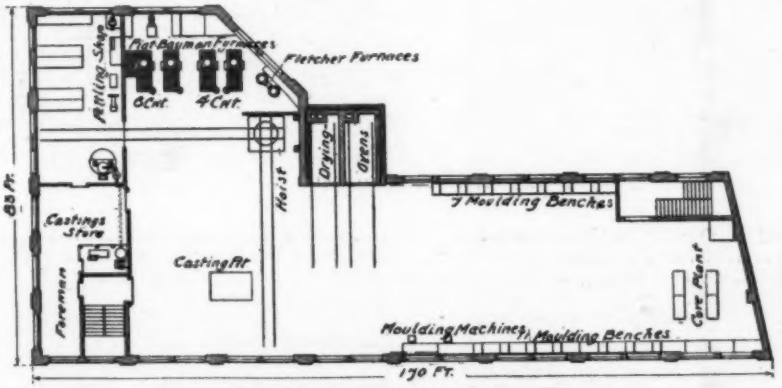


FIG. 8.—THE METAL FOUNDRY; SULZER WORKS.

ings produced, and number in the aggregate about 80 machines, the majority being used for small castings for textile machinery, motor-car parts, motor wheels, etc. The hydraulic and pneumatic plant for operating the moulding machines is housed in a separate engine room. The third division contains the cupola furnaces (Fig. 7), and the plant for preparing the moulding sand and loam. The furnaces are six in number, including a small special furnace, without fore-hearth, producing 3 to 6 tons per hour. The molten iron is transported in small tilting drums and ladle trucks (Fig. 4). The sand plant occupies two storeys, the upper one containing the mixers, ball mills and magnetic extractor, whilst on the ground floor are the jig screens for the old sand, and a washer for recovering small fragments of iron and coke from the casting waste. The fresh sand is dried in chambers and a drying oven.

The next six bays are occupied by the moulding and casting shops producing castings up to 1 ton in weight. These shops are served by electric travelling cranes up to 5 tons capacity. Two adjacent bays are devoted to fettling, and one part of the shop is set apart for the instruction of apprentices in moulding. The

FIG. 9.—FLETCHER FURNACES IN THE METAL WORKS; SULZER FOUNDRY.

a capacity of five tons per hour, supply the molten metal; and separated from these by a wide gangway is the fettling shop, equipped with two sand-blast machines and other appliances for fettling, extracting

dried, but falls apart readily after the casting is made. Two-part core boxes are used, each half of the mould being pressed separately. The necessary uniformity of wall thickness in the castings is secured

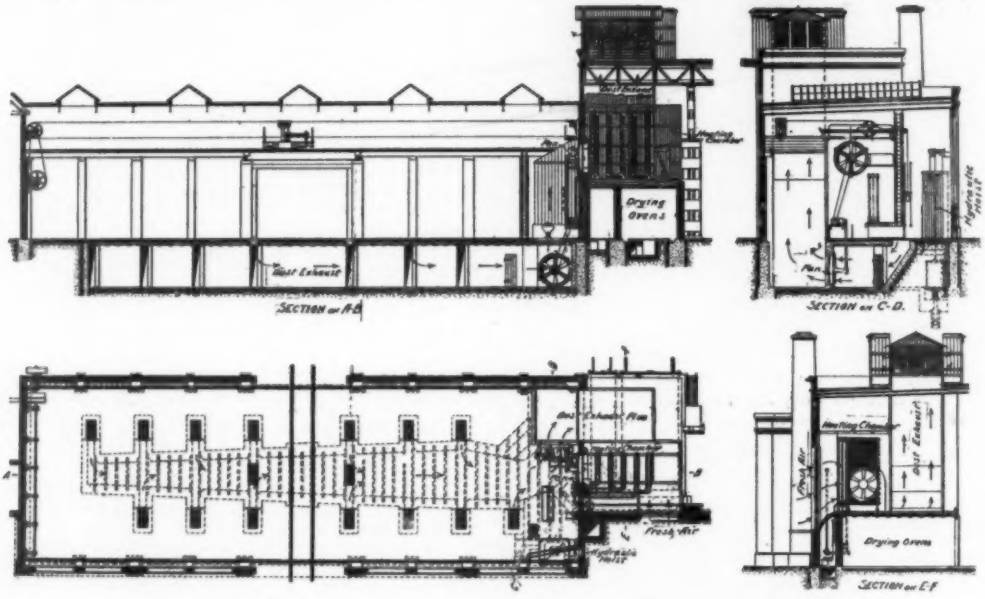


FIG. 10.—DUST EXHAUST IN FETTLING SHOP AT THE SULZER WORKS.

the cores and testing the finished radiators. The remaining space is devoted to moulding the radiators and sectional boilers, and making the cores. In the

by using a relatively small number of core supports. When fettled and polished the radiators are tested hydraulically, under a pressure of six atmospheres.

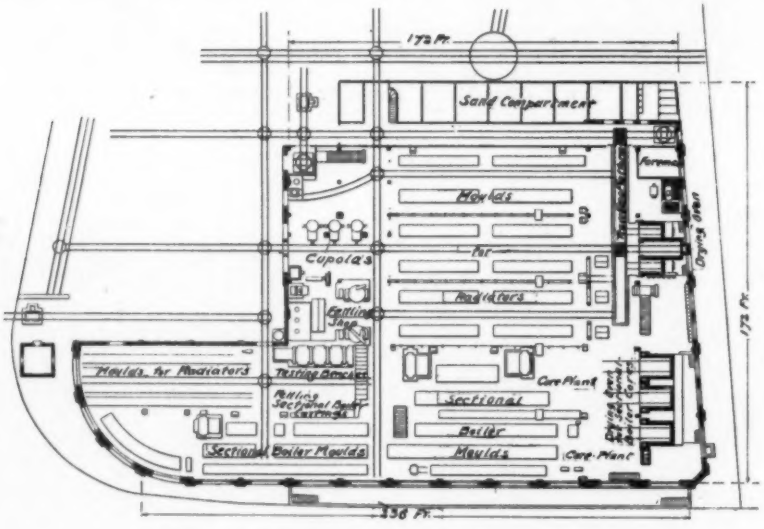


FIG. 11.—RADIATOR FOUNDRY; SULZER WORKS.

basement are the sand store, heating plant and washing accommodation.

The radiator cores have no irons, and are prepared from a special mixture which is very strong when

Turntables with hydraulic lifting devices are used for moulding the sectional boilers, as shown in the foreground of Fig. 12.

The pig-iron is stored in a large yard in front of

the foundry; and the large moulding boxes are kept in a yard, served by a crane, between the large and radiator foundries. The raw material and finished products are tested in a physical and chemical laboratory. All the fettled castings are inspected, and all wasters are booked and marked before being scrapped. Owing to the constant care taken in all stages, the percentage of waste small and medium castings is not more than 2½ per cent., still less in the radiator foundry, and practically nil in the large castings department. Special attention is devoted to training beginners, the course lasting four years and a small wage being given; all the learners have to attend the continuation school attached to the works, and are paid for their school attendance at a specified rate.

The Present Position of the Ironfounding Industry.

The ironfounding industry is advancing, but it will, perhaps, be generally admitted that it is not progressive in all the best senses of that word. Old foundries continue, and new ones spring up, while the total weight of castings made is more every year. But is the general quality of iron castings being improved, and are the ever-growing demands of the engineer for mechanical castings being met by ironfounders with the requisite skill, energy, and scientific knowledge? Every day sees progress in the engineering trade, both as regards new types of plant and improvements in existing types, and the specifications laid down by the engineer are more onerous and more difficult than formerly. There is more pressure in the cylinder, more tension on the roller, more revolutions per minute of the wheel, more weight in the hammer, and more heat in the fire.

FIG. 12.—SHOWING TURNTABLES FOR MOULDING SECTIONAL BOILERS; SULZER WORKS.

To meet the resulting demand for better and more durable castings the ironfounder has proffered old goods, and he is in great danger of being left behind. The iron he used to melt for working and bearing parts of an engine working with a steam pressure of 100 lbs. to the square inch is not good enough for the superheated steam engine, working on a pressure of 250 lbs., and by adhering to old methods the ironfounder lets the steelfounder in. In this way he loses trade, and large foundries are in danger of being left with no orders except for the commoner classes of goods, which have to be turned out under the stress of a merciless competition. Fifty years ago when the ironfounder had infinitely less to fear from competition with other metals, a better quality of mechanical castings was turned out. In those days there were not so many high-furnaces, and the operation of smelting was more confined to higher-grade ores, which yielded a better class of iron. The old method of cold-blast smelting was much more costly, but it produced a stronger, harder, and more steel-like pig, and a large percentage of this class of iron was used in the engineering castings in former days. Plant and machinery, dating from this era, when broken up to-day, yields a scrap-iron which is highly prized by our ironfounders.

The discovery of the basic-Bessemer steel-making process gave an enormous impetus to the smelting of low-grade phosphoric ores. Such pig would never have been considered for a moment by the founder of a generation ago as suitable for fine mechanical castings, but in most modern foundries large percentages of it are used, and in many cases it will be found to form the basis of the general foundry mixture. The fact is that, taken all round, the

tendency is now to use iron of poorer quality than formerly. The result is not so much to be observed in the direction of deterioration in the quality or durability of high-grade engines or machinery; this has to be and is maintained. The mischief is that iron is yielding to steel and other metals and alloys, and the nature of the process is such that neither the ironfounder nor the engineer is really alive to what is taking place; nor if they are alive to it do they fully appreciate the cause. Such a change is a loss to the ironfounder, and a source of increased expense to the engineer. It might also be further ventured that in some cases steel, brass, bronze, and other alloys, are actually being used as mechanical parts, where the best cast-iron would probably be a superior material. An engineer tries cast-iron for certain work, and finds it wanting; that is to say, it fails under some direct physical test which is easily passed by another metal. Thus, owing to the exigencies of a preliminary specification iron is rejected, although possibly were a better iron submitted by the founder the test would be satisfactorily met, and quite possibly a casting be adopted which would give better service than the steel, brass, or other metal selected. For it is known that if cast-iron, from the point of view of mechanical strength, is inferior to some other metals for certain purposes, it has certain properties which make it superior in some respects. The finest cast-iron, though showing absolute regularity of crystalline structure, is in reality a far less homogeneous material than steel or brass or bronze, and the homogeneity of these latter means that in the case of a flaw, however small, in any part of a casting the danger of its extension is far greater than in the more heterogeneous cast-iron. In at least one physical quality iron is superior to all other metals, *i.e.*, in resistance to crushing stresses.

Both the ironfounder and the engineer are responsible for this partial changing over from iron to steel, which, if it cannot be regarded at present as very serious in extent, is, at any rate, serious enough to demand careful consideration. By reason of competition and the cutting of prices the founder comes to regard it as impossible to use the finest materials; but, on the other hand, there are some cases in which the ironfounder, having delivered to the engineer castings made of the finest procurable material, gets blamed because they give trouble in tooling. Here is probably the worst aspect of the whole case. For machining good, hard iron castings, the engineer has to pay more, and rather than do so, he will specify softer and inferior castings. This consideration of a few pence per piece or a few farthings per hour in connection with the machining of important castings is not wise, for it is possible to plane, drill, or turn the hardest casting that a founder can deliver; tool steels are to be had which will meet any requirements. Since, also, cast iron is the cheapest material and is easier to procure, melt and cast, than steel, the chances of a perfect casting and promp delivery are much greater.

It is not, of course, intended to imply that cast iron can, in all cases, take the place of steel or other special metals; this would be a hopeless and fatuous contention; more is not claimed here than that cast iron has to some extent to-day lost its use in mechanical constructions through inferior quality castings having been turned out, and not through the unsuitability of iron *per se*; and that by means of a more careful selection of his raw material the ironfounder may do something to recover the lost ground, and may conceivably seize some territory on which he never set foot before. There are large margins of possible mechanical strength and physical qualities beyond the limits at present reached in iron by the average ironfounder. An iron to-day is good if it will show a tensile strength of 9 tons to the square inch, a transverse strength of 30 cwts., with a deflection of 0.35 in. on standard (British) proof bars, have a density of 7, and resist, without sweating, a water-pressure of 20 atmospheres; but it is possible to cast iron having a tensile strength of 18 tons, a transverse strength of 2 tons, with a deflection of 0.75, a density of 7.3, and resisting a hydraulic test of 40 atmospheres, all under similar conditions. These figures are, of course, not absolute, but relative; but they serve to show the range between good and really fine cast iron.

It would appear therefore that what is really needed to give a fresh impetus to the ironfounding industry in its relation to the most advanced branches of mechanical engineering is a general move on the part of founders towards the adoption of better and stronger iron for such work. In most iron-producing countries there are to be found smelters who give special attention to the production of the purest and strongest pig for foundry work, who lay down a standard of chemical and mechanical quality as regards their smeltings and strictly adhere to it. Such pig-iron commands, and always will command, a price considerably above that paid for the ordinary pig-iron of commerce. Among these special irons may be mentioned the following:—English: "Blaenavon," "Backbarrow" (Lorn), and "Low Moor"; French: "Longwy P.L.," "Mazieres," "Saut du Tarn"; German: "Ruebuländer," "Duisburger," "Mathildenhuette"; Swedish: "Björneborg," "Karlsdal."

Those who are acquainted with the class of pig-iron smelted by these firms will have a good idea of the enormous difference in quality between best cast iron and that which is represented by the average ironfounder's mixture. The output of the firms producing these proportionately higher priced specialities is probably not great, and is doubtless absorbed by a selected number of foundries doing special kinds of work. The great bulk of ironfounders certainly never have such irons on their stock.

There is room for greater enterprise amongst pig-iron makers in pushing their better and higher-priced irons in the foundry trades, for many foundries would be only too pleased to find that instead of receiving any sort of material that the smelter wished to dispose of they could rely on their requirements being properly considered. In this respect the principle which, for instance, the Frodair Iron and Steel Company, Limited, work upon, could well be adopted by other concerns. This Company offers to the ironfounder solely high-grade pig-iron; they are in touch with a large number of engineering establishments making their own castings, in Great Britain and on the Continent, and discuss with the engineers any special castings or technical difficulties which require special attention, with a view to providing the best selection of iron to meet the work. Whatever the practical difficulty in connection with an iron casting weighing anything from 50 up to 30,000 lbs., or whatever the specification as to mechanical qualities which the finished piece had to pass, the Company consider it in detail, and suggest the best iron for their clients. This system, we understand, has proved successful, and is thoroughly appreciated by those with whom they treat.

It would be pleasing to see smelters as a whole more eager to meet the requirements of the foundryman, with a view to maintainng the standard of his work; and further it would be a source of mutual advantage.

Brass Foundry Crucible Furnaces.

(*Continued from page* 22.)

Melting by means of tilting furnaces has now reached a scientific and practical stage, and has been applied with marked success throughout this country and abroad for general brass-foundry work. Oil-fired crucible furnaces in this country have been a long time reaching their present practical designs, this no doubt being largely due to the uncertainty of the fuel supply. The comparatively high cost of a satisfactory oil has also prohibited their use, but the deciding point against the adoption of this system of melting has been the severe conditions usually imposed upon the crucible itself. At the present time, however, there are signs that the supply of a suitable fuel oil may be relied upon with greater certainty, for the cheapest gas works by-product oil can now be burned with excellent results. The tilting furnaces, here described and illustrated, which were designed for coke fuel, have also been adapted for oil and power gas.

Specially prepared crucibles can also be used without fear of perishing; in fact, the average life of crucibles in a well-designed oil furnace will often be greater than that with a coke-fired furnace. On the other hand, an unsuitable burner, or an incorrect mixture of oil and air, may readily be responsible for the quick failure of the crucible and prohibitive cost of melting. In the tilting furnace under discussion, when adapted for oil fuel, the following average results may be expected. With ordinary grey cast iron a 340-lb. charge can be run down in 2 hours, with an oil consumption of 2.5 gallons per 100 lbs. metal; when making gunmetal a heat of 400 lbs. can be obtained in 1½ hours, with a ratio of 1.5 gallons oil to the 100 lbs. metal melted.

In oil furnaces, the use of crucibles ensures the more even heating of the metal, and the loss of volatile constituents in mixed scrap is curtailed to a minimum, whereas with direct-flame furnaces, without crucibles, the "loss" can reach a very high figure, so much so that it often becomes necessary to adopt special means of trapping the zinc oxide fumes, and so in a measure to balance the value of such residues against the metals volatilised during the melt. This excessive loss can only be avoided by the protection of the metal in a crucible, when the running costs of an oil-fuel melting plant on this system will work out very satisfactorily. Such a furnace is reproduced in Fig. 8.

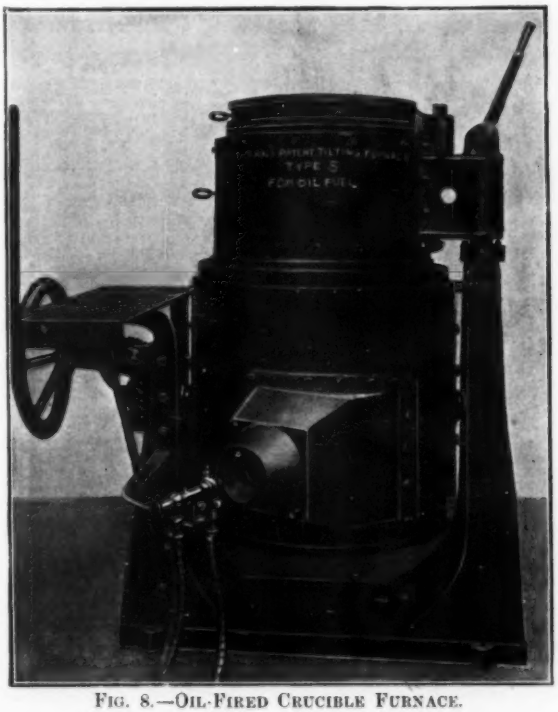


FIG. 8.—OIL-FIRED CRUCIBLE FURNACE.

A range of pull-out pit furnaces, each fitted with its own oil burner, may sometimes be of convenience for special purposes; these furnaces may be all of one size or graduated in dimensions to take the crucibles of varying capacity to suit the output of the foundry. The design of such furnaces has been developed with a view to reducing the working costs of oil furnaces as much as possible, the idea being to apply only one burner to a furnace chamber of such dimensions as will accommodate three separate crucibles. The economy of this method of firing will be readily understood when it is considered that one burner only is in use instead of three, the amount of air supplied under pressure is one-third of that

required for three burners, and the oil consumed not more than half the amount that would otherwise be the case.

Questions have often been raised in this country by metal founders regarding the relative costs of melting by liquid and solid fuel, and why the advantages attributed to the former have not enabled manufacturers of furnaces to achieve the success that is claimed on the Continent and in the United States for oil furnaces. There are one or two installations of tilting and lift-out crucible furnaces at work in the British Isles burning oil fuel, but the more general adoption of the system is still restricted, for the reasons already given.

Among the chief features and advantages of oil crucible furnaces are: —(1) The absence of all coke ash and clinker and the consequent saving of crushing, washing and remelting, and of the bulky bins required for the storage of solid fuel; (2) the absence of machinery and labour for coke breaking.

The oil can be delivered in tank wagons and pumped or raised by air pressure into the oil cisterns. In most oil-burning systems, as applied to melting furnaces the oil is fed to the burners by gravity, or under an equal pressure with the air supply, the latter being obtained by means of a branch connection from the air reservoir to the oil supply tank. Furnaces are also constructed to run with a considerable pressure on the oil supply and in this case pumps are requisitioned for pressures up to 200 lbs. per square inch, the air being supplied by a simple positive blower. On the other hand, when compressed air from 10 to 40 lbs. per square inch is adopted, the oil can be fed by gravity alone. One or the other of these methods is usually employed to thoroughly pulverise the cheap thick oil used. The only oil furnaces possible in this country are those which can be fired by means of the "residue" class of liquid fuel obtained from gas works or oil distillation plants; residues being the thick cheap oils left after the higher volatile hydrocarbons have been extracted from the natural oils.

Fuel for fuel, it will be found in this country that the cost of oil for crucible melting furnaces will be, according to locality, from 10 per cent. to 50 per cent. greater than foundry coke, but where other advantages outweigh this consideration and a reliable supply is assured, a system of oil fuel firing can be beneficially adopted. Oil furnaces can be started in the morning when the works open, with little delay, and several can be looked after by one furnace man. Some idea of running costs per 100 lbs. metal melted, based on a 400-lb. size Morgan's patent tilting furnace are given below, the metal taken being an ordinary grade of good quality brass: —

	Per 100 lbs. metal melted. Pence.
Crucibles, with stands, muffle rings, etc. ...	5.475
Fuel, at 2.63d. per gal. (1.5 gals. consumed) ...	3.945
Power. 6 h.p. for air compressor (power for pumps with positive blower would be about the same)	1.50
Labour for operating, one man at three furnaces at 30s. per week	1.11
Linings—Sectional firebrick lining...	0.612
Labour for re-lining	0.084
Labour and material for repairing and patching the lining during its life	0.281
	13.006

The approximate cost of melting in tilting furnaces, taking full advantage of their maximum output and the cost of fuel, etc., as given above, would be about 1s. 1d. per 100 lbs. of metal melted, or roughly between 25s. and 30s. per ton according to the foundry conditions.

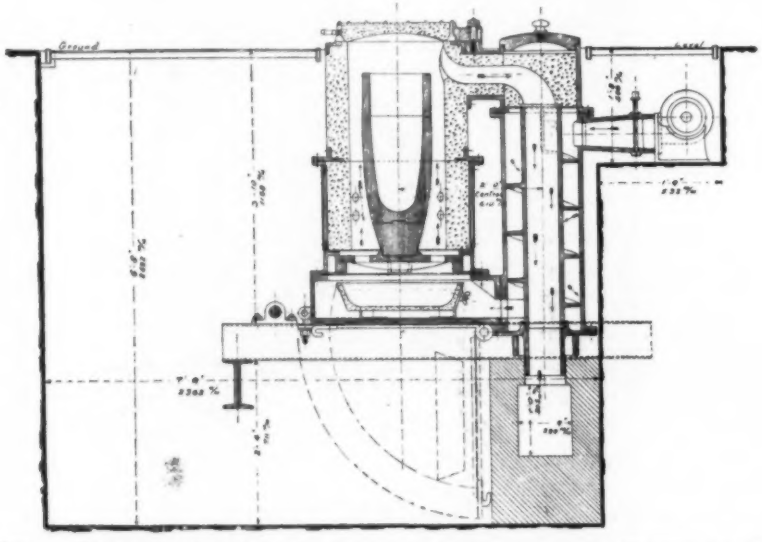


FIG. 9.—SECTION OF PULL-OUT PIT FURNACE SHOWING SYSTEM OF REGENERATION.

Oil burners and furnaces should be so proportioned and constructed as to maintain combustion at the required temperature, with a reducing atmosphere in the melting chamber. Not only will this greatly prolong the life of the crucibles, but oxidisation of the metal, which is a more serious matter, will thereby be prevented.

Figs. 10 and 11 illustrate a further useful type of crucible tilting furnace (type "S"). This has been designed to take up less space than those fitted with the regenerative flue shown in Fig. 9, which gives a sectional view illustrating the system of regeneration which is applied to the furnaces described in the earlier part of this article. In the furnace shown in Figs. 10 and 11 the regenerat-

ive flue has been omitted; the incoming air is heated between the two casings of the furnace body by the heat conducted from the interior. The waste gases pass out through a central opening in the cover of the top preheating section, wherein a muffle ring is placed in the manner adopted in the standard design. These smaller furnaces do not possess the advantage that the gases and fumes coming from the fuel and metal are drawn downward into the usual underground flue, and so to the chimney; but although the gases are emitted through the hole mentioned, they can be entirely collected and withdrawn through a telescopic tube chimney fitted above the furnace.

The foregoing only touches briefly on some of the different crucible furnaces that are available for the founder, and all of which have their particular functions and uses, but it will probably assist those who contemplate the reorganisation of their melting plant; for when it is proposed to erect a new foundry, or additions are in view, the question of what type of furnace will offer the greatest advantage for the particular class of work to be dealt with should not be passed over without very careful consideration. In the past there was often no alternative, and the solution was an easy matter, for the old built-up pit fires were all that could be obtained in the way of crucible furnaces. In later years, however, works managers and engineers have given their foundry department a great deal more attention, the result being that various types of economical furnaces are now available, each designed for a special purpose, and to a judicious choice of initial melting plant the successful working of a foundry is very largely attributable.

Further, it may be truly said that if the installation of unsuitable furnaces is still continued, the annual waste through the accumulation of the many small losses may often amount to several times the extra cost of an up-to-date plant.

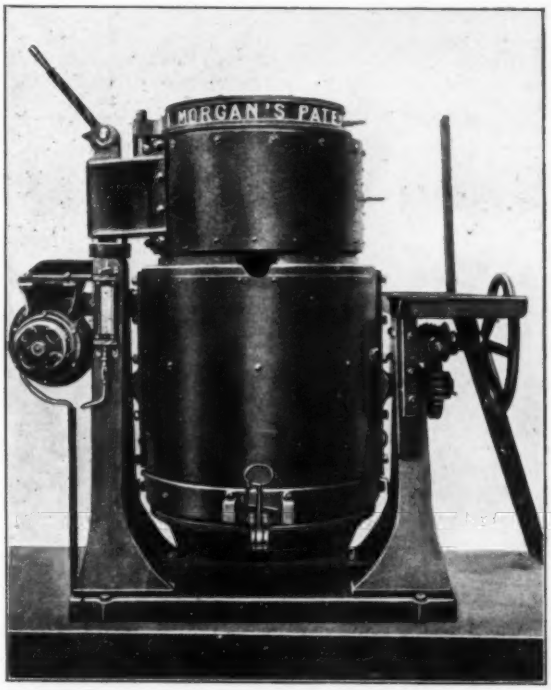


FIG. 10.—CRUCIBLE TILTING FURNACE; NORMAL POSITION.

A Process for the Tinning of Metal.

A handy process for the tinning of iron and other metals would often be very useful to foundrymen for a number of purposes, such as for tinning chaplets and other articles. The Metal-Ausprich S,ndikat of Berlin has recently put on the market a process that opens up a number of possibilities in this direction. It differs entirely from the ordinary process of tinning. The tin is first rubbed fine like common bronze powder and is then worked into a paste or paint. The mixture may be made from pure tin, from tin and lead, or from tin, lead, and zinc. After the article has been painted with this mixture it is heated in a muffle or flame until the coating melts. The article is then rinsed in water and, if necessary, brushed. Cast-iron articles cannot be tinned without first copper-plating them. It is claimed that this covering is no more porous than tin applied in the usual manner, and that the articles can be subjected to drawing or pressing operations or to twisting or bending without flaking off the coating. Cleaning the articles before tinning, either by polishing or pickling, is, of course, necessary, as in every similar process.

Influence of Top-Lag on the Depth of the Pipe in Steel Ingots.*

By Henry M. Howe.

In my original paper, "Piping and Segregation in Steel Ingots," I pointed out, among other things that, in view of the slighter stretching (virtual expansion) of the crust, and greater opportunity of sagging, there should be less piping in broad than in narrow ingots, and less in slowly-cooled ingots, *e.g.*, those cast in pre-heated sand moulds, than in those which cool quickly, *e.g.*, those cast in iron moulds. Mr. A. A. Stevenson said that neither of these predictions agreed with his own experience. In particular, in a picture which he showed of a wide and of a narrow ingot cast from the same ladleful of steel, the wide ingot had certainly piped much more deeply than the narrow one.

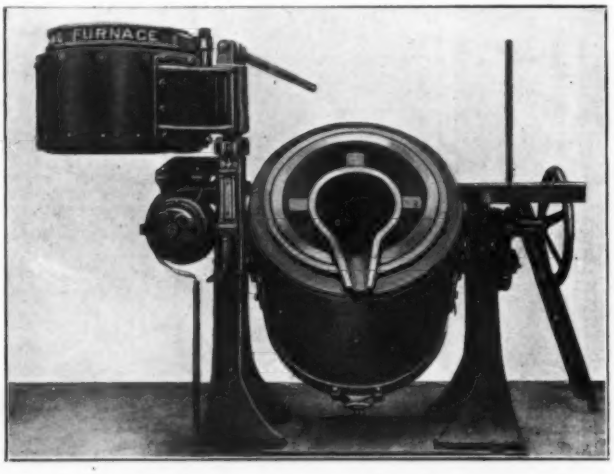


FIG. 11.—CRUCIBLE TILTING FURNACE; POSITION FOR POURING.

At the time I did not see the explanation of these discrepancies, but further reflection makes it evident. One of the most important elements in determining the depth of the pipe is the degree of "top-lag," that is, the degree to which the solidification of the top of the ingot lags behind that of the bottom. Through this lagging the steel of the upper part of the ingot is able to run down and fill the pipe below as fast as it forms. To the importance of this lagging I called attention in my original paper.

Sand v. Iron Moulds.

If we compare two similar ingots, one cast in an iron and the other in a sand mould, we see that the top-lag is much greater in the former than in the latter, because in the former the lower part of the ingot is cooling off fast while the metal is running into the upper part. It is perhaps easier to look at this as a case of the solidification of the bottom out-running that of the top, which is nothing but the other aspect of top-lag. This stronger top-lag in case of iron than in case of sand moulds may well outweigh the influence of greater opportunity for sagging which the sand mould gives. It is to this effect that I refer the discrepancy between Mr. Stevenson's observation and my prediction. The latter ought to have been modified so as to take into account the greater top-lag in the iron mould. If this influence can be cut out, then the effect of greater opportunity for sagging in the sand mould should become evident in the shortening of the pipe. In experiments which I have since tried I have found this to be the case.

A striking example of the shortening effect of slow cooling, which, as I asserted, ought to shorten the pipe, is given in the case of ingots which solidify slowly in the soaking-pit. Their pipe is much shorter than that of ingots which solidify rapidly in the outer air.

Wide v. Narrow Ingots.

The case which Mr. Stevenson gives, in which a narrow ingot piped much less deeply than a wide one cast from the same ladleful of steel, is seen, on further consideration, not to be a fair contradiction of my prediction, for two reasons. In the first place, the fact that these two ingots were cast with the wide end up tends to shorten the pipe much more in the narrow than in the wide ingot. I have insisted on the effect which having the large end up has of shortening the pipe by means of top-lag, though I had not at that time devised this term. It is clear that the effect of this taper is much greater in a narrow than in a wide ingot. The taper is usually the same, and hence the absolute widening of the top is the same, in narrow as in wide ingots, and hence it forms a much larger proportion of the width of the ingot in narrow than in wide ingots. But the mere fact that the widening at the top bears a greater

* From the "Transactions" of the American Institute of Mining Engineers.

proportion to the average width of the ingot in narrow than in wide ingots has for its clear result that this widening causes more top-lag in narrow than in wide ingots. The effect of width, as such, on the depth of the pipe can be shown only when the effect of other variables is cut out. Now in this case the greater top-lag caused by the taper in the narrow than in the wide ingot directly opposed the effect of width, as such, in permitting sagging and in lessening crust stretch. In order to test the effect of width, as such, parallel-sided ingots should be used, and the effect of other variables should be excluded. This I have done in certain preliminary experiments, which, as far as they go, support my prediction that width tends to shorten the pipe.

In case the ingots are tapered in the opposite direction, with the large end down, this taper, because it tends to lengthen the pipe, and because the effect of taper should be inversely proportional to the width of the ingot, should tend to lengthen the pipe more in narrow than in wide ingots. In fact, this influence is relatively unimportant in wide ingots.

The second reason why the evidence given by Mr. Stevenson's wide and narrow ingots is not valid is that the narrow ingot was poured much more slowly than the wide one, and this in itself, as I pointed out clearly, has an important effect in shortening the pipe. It was evidently poured much more slowly than the wide ingot, because the two were in the same bottom-cast group, and consequently the steel must have entered the narrow ingot very much more slowly than the wide one.

Everything else being equal, the more rapid cooling of the bottom of a narrow than of a wide ingot tends to give the former greater top-lag than the latter, and thus to shorten its pipe.

Looking at it in a general way, we see that narrowness in one way tends to shorten the pipe and in other ways tends to lengthen it. On one hand, in that it leads to (1) the more rapid cooling of the bottom, it increases top-lag and thereby tends to shorten the pipe. On the other hand, narrowness tends to lengthen the pipe (2) by leading to relatively great crust stretching (virtual expansion), (3) by giving little opportunity for sagging, and (4) (for given rate of pouring) by leading to rapid rise of the surface of the metal, and in this way lessening the top-lag. My original prediction, supported by the observations which I had then made, was based on these latter considerations, (2), (3), and (4), and overlooked consideration (1). Now it may be shown hereafter that my prediction does not hold true under certain comparable conditions, or even under most comparable conditions. But Mr. Stevenson's evidence does not prove this, because if my prediction is true that the net effect of narrowness, as such, is to lengthen the pipe, nevertheless this effect might be completely masked under his conditions by the joint effect of (1) his having the large end up and (2) his pouring more rapidly into the wide than into the narrow ingot, because both of these things should tend to give the narrow ingot the shorter pipe of the two.

In other words, his conditions introduced certain accidental concomitants of narrowness, which concomitants clearly tend to shorten the pipe in his narrow ingots, and thus to mask the influence of narrowness as such. The fact that in the presence of these pipe-shortening concomitants the predicted pipe lengthening effect of narrowness, as such, is not seen, is no proof either that that effect does not exist or that it would not be seen when such masking concomitants are absent. I hope to present further data on this subject soon.

The Heat Values of Fuels.

Before the Sheffield and District Branch of the British Foundrymen's Association, at the general meeting held in the Department of Applied Science, St. George's Square, Sheffield, on January 22nd, Mr. F. K. Knowles, B.Met., of the University of Sheffield, lectured upon "The Heat Values of Fuels, and the Methods of Estimation." The President of the Branch, Mr. Percy Longmuir, B.Met., occupied the chair. Mr. Knowles dealt in a lucid manner with the various units of heat and temperature scales, and followed with explanations of the terms—calorific and evaporative power. The characteristics of the various fuels—coal, charcoal, anthracite, coke, and gas—were described, both from chemical and physical standpoints, and cokes for different purposes were considered. Thus crucible coke should be tender and porous, so as to give rapid combustion and give high local heat. Coke for blast furnace work should be strong and hard, but yet permeable, and favour the formation of carbon-monoxide gas during combustion. For cupola practice the coke should be hard but not permeable, so that combustion takes place on the surface of the coke.

Various calorimeters were exhibited and described, and actual demonstrations were made by means of the Lewis Thompson and the Darlington calorimeters, whilst Mahler's bomb instrument was fully explained.

A feature of the lecture was the result of experiments carried out at the University, comparing the calorific power of certain cokes, as actually determined, with values calculated according to the chemical composition. The following table summarises the results:—

Coke.	Analysis.			Evaporative Power.		
	Ash.	Moisture.	Sulphur.	Calculated from carbon per cent.	Determined in Burnt Calorimeter.	Difference.
Eckington ...	3.12	0.90	0.81	14.47	14.41	0.06
Tinsley Park ...	4.68	1.85	0.33	14.07	13.78	0.29
Oswaldtwistle ...	6.63	0.85	0.77	13.92	13.74	0.18
New Charleston	4.68	1.40	0.89	14.13	14.10	0.03

After further advice on the choice of cokes according to physical characteristics, Mr. Knowles closed his admirable address with an appeal for the members, especially the younger members, to take up the study of the technical side of their craft. A suggestion as to the possibility of forming a class designed particularly for foundry workers was seized upon with avidity in the discussion which followed the reading of the paper, and the matter is to be carefully considered by the Council. Considering the unique possibilities afforded by the Sheffield University in this direction, it is to be hoped that the matter will result in a definite advance being made.

Moulding to Obtain Clean Castings.

The Application of Skimming Gates.

By A. Napier.

In both iron and brass foundry practice there are a number of precautions to be taken in order to obtain clean metal for the castings, and according to the nature of the work these precautions are more or less closely observed. In brass and bronze work it is usually very important to clean the metal of all dirt, which can be done by preventing oxides forming on the surface during melting, reducing the oxides and dross by deoxidisers, and by arranging the mould so that any dirt is cleared or skimmed from the metal poured in. The writer wishes particularly to draw attention to the fact that while careful melting or the use of a deoxidiser will often go a long way to secure

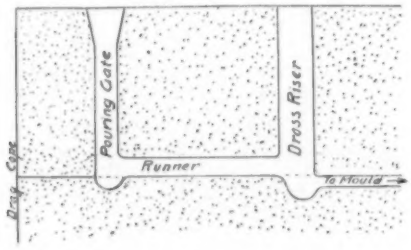


FIG. 1.

a good casting, more is required in first-class work than the use of any one of these precautions. Many moulders seem to be under the impression that, provided the mould is completed according to the pattern and a pouring gate and perhaps a riser put on, it rests with the melter to provide the metal in a sufficiently clean condition to give a good casting. But they forget, or do not understand, that the man with the crucible cannot do more than give clean metal as it leaves his hands; he cannot deal with any of the other factors that go to create dirty castings. For instance, the

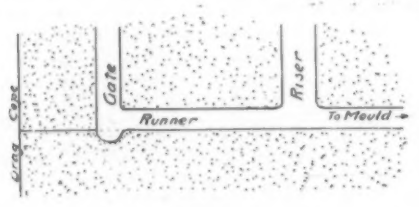


FIG. 2.

metal, particularly if it is manganese-bronze, an aluminium or other similar alloy, commences to form a scum on the surface through oxidation directly it leaves the furnace, and this continues during the pouring, and so long as the molten metal is in contact with the air. Then, again, dirt is likely to be gathered from the mould itself or even from the crucible, and this enters with the metal into the mould unless means are taken to prevent it. It lays with the moulder to provide the means for skimming this dross and dirt from the metal and clearing any that passes into the pouring gate.

In an article in the December issue of the FOUNDRY TRADE JOURNAL, the writer, in dealing with manganese in foundry work, remarked on the necessity of constructing and arranging the gates and runners of the mould in such a way as to collect the dirt which almost invariably forms on the metal through oxidation, or gathers from the mould as the metal is poured in. The brief mention which this subject was given does not do justice to it, and it may now be considered separately and more fully, dealing more particularly with the moulder's duties in the matter, so that he may not be troubled with dirt entering the casting and lying in wait for the machining operation to reveal it. With some little differences, the methods which are employed in moulds for iron castings can be

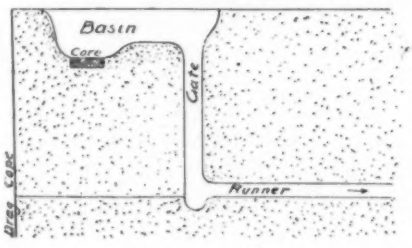


FIG. 3.

equally well employed for castings of other alloys, such as brass and manganese-bronze. Skimming gates, the purpose of which is to clear dirt from the metal, are often employed in different forms in the ironfoundry for particular work, but in the brassfoundry, where they are equally important, and perhaps in some cases more necessary on account of the nature of the metal, their use does not appear to be so well appreciated. This may possibly be on account of the fact that brass-

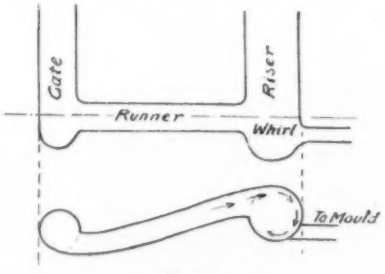


FIG. 4.

foundry work on the whole is much smaller than iron work, and so requires smaller quantities of metal, which are more readily and easily handled. But, nevertheless, where any but small castings are being made, skimming gates are most desirable if good results are wanted.

In considering the question of cleaning dirt from the molten metal it must be remembered that all the impurities referred to are lighter than the metal, and when released tend to rise to the surface. This important feature underlies the construction and application of skimming gates, and must be clearly borne in mind when such work is being taken in hand. Unfortunately, this feature is not always understood, and

moulders turn out what would be cleverly constructed arrangements for skimming the metal if they did not run counter to this one essential. Needless to say, unless it is properly observed, any ingenuity on the part of the moulder will be wasted. Briefly, a skimming gate is an arrangement of gates, runners and risers which will effect the separation of the impurities

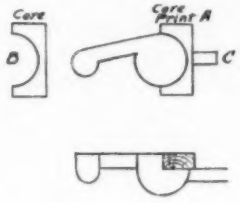


FIG. 5.

before the metal enters the mould proper. The method in which the dirt is cleaned from the metal will be seen from the simple design shown in Fig. 1. The metal on being poured passes along the runner to the bottom of the riser and to the mould. But on reaching the riser the flow of metal to the mould is reduced, and is only drawn from the bottom of the runner stream

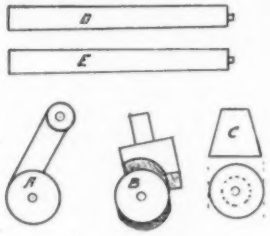


FIG. 6.

where the cleanest metal is, while the lighter dirt, tending to rise to the surface of the metal, finds its way up the riser as the easiest outlet. Strange to say, the simple principle upon which this arrangement is constructed is often not understood by the moulder, and the arrangement shown in Fig. 2 is moulded instead. The result is that a practically clear way is

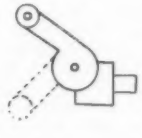


FIG. 7.

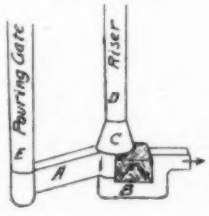


FIG. 8.

left for the dirt to enter the mould instead of the metal beng drawn from the bottom of the stream.

The effect of drawing the molten metal for the mould from the bottom of a quantity of fluid metal can be obtained by the use of runner basins, such as that shown in Fig. 3. When the basin is kept full of metal the actual flow into the mould does not come in contact with the air. A runner basin similar in form to that shown in Fig. 3 and other illustrations, is usually attached to arrangements of skimming gates if the quantity of the metal to be poured justifies it. In the bottom of the basin, where the stream of metal strikes it, either a core, or thoroughly dried ordinary or loam bricks, should be inserted; these prevent the stream of metal cutting into the basin. It is better practice to evenly ram the box for the basin full of sand, and then cut out the desired shape, as this gives a more reliable result than ramming the bottom first and then pressing the sides into position afterwards. The arrangement shown in Fig. 1 materially assists in clearing the

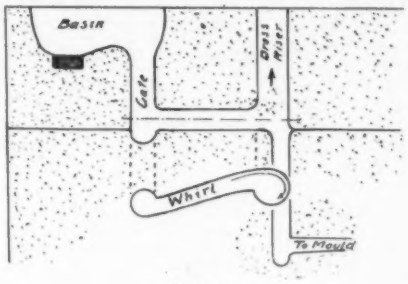


FIG. 9.

metal, but as an additional means the runner may be built in the form of a whirl—that is to say, constructed so that the metal in travelling along it is given a whirling or rotary motion. This has the effect of assisting any dirt that may be present to come to the surface and so more readily get into the dross riser This whirling motion is obtained by constructing the runners as shown in Fig. 4, the metal taking a motion as indicated by the arrows. A convenient way of obtaining this arrangement is by ramming up a pattern of the skimming gate with the pattern to be moulded. This pattern is shown in Fig. 5, the core print A allowing the core B to be placed in after the pattern has

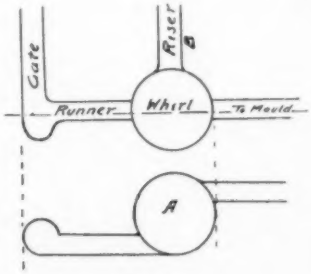


FIG. 10.

been withdrawn, so that the metal passes under the core B into the mould. This principle was employed in the skimming gate invented by the American foundryman, Joseph F. Renshaw, and patented by him in 1882. This skimming gate, which is known as the "Renshaw," finds considerable favour with founders of manganese-bronze, brass, and similar alloys, and as the patent has now expired some time, the design may be adopted by anyone. The apparatus required to form the skimming gate is shown in Fig. 6, comprising the skimming gate proper, A B, the cap C, and the pouring gate and riser sticks, D and E. The object of the construction will be seen from Fig. 7, which indicates the way in which the skimming gate may be accommodated in any desired position in the mould. Ths swivelling (see Fig. 7), is accomplished by the two parts A B (Fig.

6), being held into position by a centre screw, which also allows of them being fixed in any desired position after the setting. The cap C takes the position shown in Fig. 8, under the riser and assists in the escape of the dross upwards by allowing an easier passage. F represents a core print which is inserted in the gate as shown, so that the metal passes under the core that takes its place. This core should be made of a coarse, open mixture, and be well vented so that it will not blow. It may be made in a special iron core-box and clamp designed by the inventor, or in any form of core-box, the core being a simple one to make.

This form of skimming gate pattern could be made

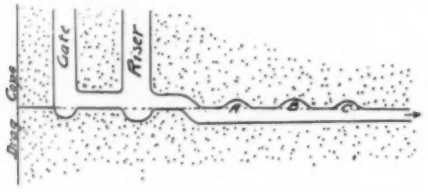


FIG. 11.

in one piece, instead of being made to swivel, the riser and pouring gate sticks, of course, being separate and of wood; but the advantages of the other form are obvious, as it can be accommodated in places where a fixed pattern would be awkward. A suitable range of sizes of these gate patterns should be kept in the foundry so that the most applicable size could be used on each job. The pattern of the skimming gate should be placed bottom side upwards on the match board and rammed up with the pattern, and being made with a good amount of draft is easily removed from the sand. The holes in the pattern shown in Fig. 7 accommodate the pins on the ends of the pouring gate and riser sticks and also serve as draw holes, particularly if threaded to take a screw-rod. It will be noticed that the principle of a small section channel leading to the mould from the skimming gate, as mentioned in connection with Fig. 1,

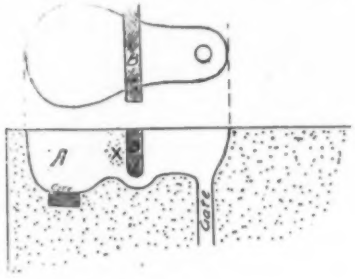


FIG. 12.

is employed here also, the combined effect of this, the skimming core and the whirl being to produce very clean metal in the mould.

A number of patent gates have been produced at different times, but many of them while theoretically offering some advantages, have been found impracticable in actual practice, often entailing too much labour in moulding and arranging. No gate, to be successful and useful to the foundry, must involve a lot of work, or it only gets used under exceptional circumstances. For heavy work it is best to use the gatings shown in Figs. 3, 5, 8, etc., outside the flasks, though for light work it is usually more convenient to mould the pouring-gate, skimming-gate, etc., with the pattern in the flask. But the distinction between light and heavy work must be well observed; the metal should be allowed plenty of room to get to the mould in the latter case, as the pouring heat is usually duller than for light work, and the metal is liable to become too sluggish to fill sharply every corner of the mould if it is only let in slowly. Too much must not be expected from skim-gates with heavy work, for though they serve to clean the metal as it passes into the mould they cannot deal with the dust and dirt gathered from the surfaces of the mould itself. This feature is not prominent with small work, for the surface of the mould is smaller and the metal quickly takes its place.

In Fig. 9, another arrangement of gates and runners is shown. This presents much the same features as that of Fig. 1, with an additional runner. This is made considerably smaller than the first runner or the riser, thus allowing the dirt to escape upwards, as shown, and drawing the metal finally from the bottom. The whirl is introduced as shown, the metal taking a rotary motion as it reaches the riser, and so sending the dirt to the surface. Another form of constructing this whirl (shown in Fig. 10) is by ramming up a ball to form the chamber A. The tendency here is for the lighter particles of dirt to be held in the centre of the whirling ball of molten metal while the stream is being poured.

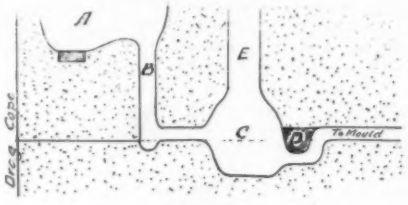


FIG. 13.

This is claimed to be sufficiently effective for small work to serve without the riser B, though this riser is advisable with work of any considerable size. As an additional precaution may be used the arrangement shown in Fig. 11, particularly where a long runner is employed. A long runner is often favoured for brass and similar work, and in such cases what are termed blind risers (A, B, C) assist in trapping any dirt that gets into the runner. Where a number of castings have to be turned out, a pattern can with advantage be made and rammed up with the mould. With manganese-bronze work, however, it is better to use a suitable arrangement of skimming gates than a long runner, as the latter tends to cool the metal too much.

Before concluding this subject, it may be as well to refer to the use of skimming cores in the pouring basin; these cores are particularly useful where direct runners are moulded. The effect of a skimming core is illustrated in Fig. 12, which shows a basin with a core B set across it. The metal passes under the core B into the other side of the basin and into the pouring gate. A series of these skimming cores could be used in a long basin, the metal passing under each in turn before entering the gate, but the chilling effect experienced with a long basin does not recommend it for brass work. By the use of these cores any dirt that is poured into the basin with the metal is retained at X (Fig. 12), though this, of course, does not deal with any dirt that is gathered afterwards.

As a means of skimming nearer the actual casting the method shown in Fig. 13 has many points to recommend it. The skimming arrangement is placed

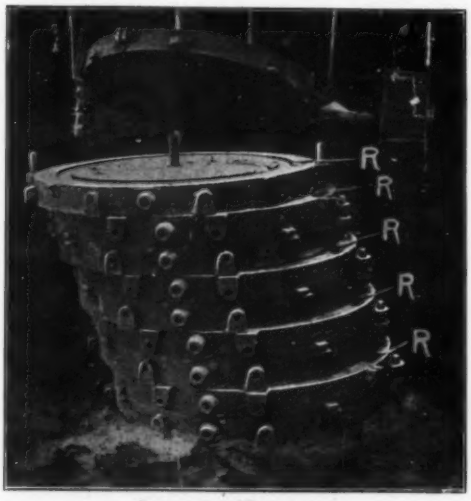
under the cope, the metal flowing into the basin A, and down the gate B, along to the chamber C, and under the core D to the mould. A riser E is placed over the chamber and allows the dirt collected by the core to rise clear of the incoming metal.

The foregoing notes by no means cover all the means whereby the moulder may provide against the occurrence of dirt in the mould; but the principles which have to be observed in arranging the gates and runners are sufficiently explained to show in what direction to work. The dross risers shown in the various illustrations, it may be mentioned, do not to any great extent serve the purpose of feeding heads or risers whose purpose is to supply extra metal to the heavy parts during cooling and solidification. These latter are outside the scope of this article; their size, position, etc., are matters for the judgment of the moulder, and depend on the shape and size of the casting, their purpose being to assist in getting solid castings free from internal strains set up through the irregular contraction of the metal in cooling. Skimming gates and the risers attached to them are intended to deal with the almost inevitable dirt and dross that occurs in the metal, so that it shall not enter the mould and cause dirty or weak places in the casting.

The Stacking of Moulds.

By G. Buchanan.

The increased use of the moulding machine for repetition castings brings in its wake the need of larger moulding floors to accommodate the greatly increased output from these machines. This problem of more room for our moulds is being solved in several different ways. One of the principal methods employed and which meets the case in some measure is the continual casting of the moulds. This method entails cupola melting the whole of the day, and where this method is already in use (as it is in many large plants), the need for larger floor space is not felt, as the moulds are cast a few minutes after being made, and as soon as possible the boxes are shaken out and the sand mixed ready for use again. Several firms who, in the ordinary course, cast their work from, say, 3 to 5 o'clock in the afternoon, have, with the advent of the moulding machine, taken to pouring off twice each day, with satisfactory results.



STACKING MOULDS.

The above methods call for no change in the actual making of the moulds. But the problem has been tackled with some degree of success by a change in moulding-machine methods. Multiple moulding is, for a limited class of castings, a success, but to attempt to apply this method generally is entirely out of the question.

Another method of stacking moulds has been in use in at least one foundry for some time. This stacking of moulds is an attempt to solve the floor space problem for certain classes of castings made on the stripping plate moulding machine. The illustration shows a stack of moulds five high. The moulding boxes measure 3 ft. 6 in. in diameter, and are used to mould chaff-cutter fly-wheels. Another set is also in use for the moulding of mowing machine road wheels. The only change in moulding is that the back of the moulding box is scraped off level with a metal straight-edge, and placed by means of a hoist on the top of the first mould. The moulds are run from the edge as shown at R on the illustration. As each mould is cast separately, the height of the stack is only limited to the capacity of the casting arrangements. For the moulds on which this method has been used it has been found entirely successful, and a floor space of 40 ft. by 9 ft. has been reduced to 16 ft. by 4 ft. There is also a 10 per cent. increase in the output due to the working of this method.

THE announcement has been made of an amalgamation in the Staffordshire tube trade. The combining companies are Messrs. Accles & Pollock, Churchbridge Works, Oldbury; the Oldbury Tube Works Company, the Oldbury Steel Conduits, Limited, Paddock Works, Oldbury, and Merriman, Limited, Oldbury. The new concern is known as Accles & Pollock, Limited, and has a capital of £40,000, of which £22,500 was raised in £1 ordinary shares, and £17,500 in debenture and preference shares, with Mr. T. Pollock as managing director.

IMPORTANT extensions are about to be carried out at the St. Peters' Works, of R. & W. Hawthorn, Leslie & Company, Limited. The site of the late Tyne General Ferry Company, and also that of Fletcher's Forge, which adjoin the St. Peters' Works on the west, have been acquired, and here it is intended to lay out a large boiler shop some 300 ft. long and 70 ft. wide. The existing boiler shop is to be converted into a department for turbine work, of which the firm now turns out a great deal, while the whole establishment is to be remodelled and fitted with the latest plant and tools.

The Institute of Metals.

The Winter Conference of this Institute, which was held in London during last month, has made it clear that in many respects this young organisation is beginning to fulfil the aspirations of those who called it into being. The number of members increased during last year to over 500, an eminently satisfactory figure after an existence of only eighteen months, and the financial position is quite sound. Sir Gerard Muntz, in his Presidential address, realising that the intimate association of scientists, manufacturers, and users of the non-ferrous metals had not yet been altogether brought about, put in a plea for closer inter-communication and greater confidence, which it is hoped will not fall on deaf ears. At the present time it is obvious that the scientific element rather holds possession of the field, and the papers submitted to the present Conference are in the main scientific rather than practical. This tendency will no doubt be corrected as time goes on, and at least the Institute possesses the advantage of having as its President, in succession to Sir William White, an eminent manufacturer in the person of Sir Gerard Muntz. The new President touched some points of practical interest in his inaugural address, and his suggestion in reference to the formation of local centres of the Institute in big provincial centres is likely, it is understood, to bear fruit.

The Annual General Meeting opened in the hall of the Institution of Mechanical Engineers, Storey's Gate, S.W., on Tuesday. Sir William White, the retiring President, who occupied the chair at the opening of the meeting, moved the adoption of the Report of the Council for the year 1909. The Report stated that the membership of the Institute had increased during the year from 355 to 505. Comparing these figures with the earliest stages of progress in the history of other technical institutions, the rate of growth in membership was regarded as very satisfactory.

Sir William White said that it had been decided by the Council that the Institute should be incorporated, and he proposed the resolution necessary to give effect to that decision. The resolution was seconded by Sir Gerard Muntz, and unanimously carried.

The result of the ballot for the election of officers was then announced, and the list now stands as follows:—*President*: Sir Gerard Muntz. *Vice-Presidents*: Mr. J. D. Bonner, Professor H. C. H. Carpenter, Professor W. Gowland, Professor G. H. Huntington, Engineer Vice-Admiral H. G. Oram, and Sir Henry Wiggin. *Members of Council*: Mr. T. A. Bayliss, Mr. G. A. Boeddicker, Mr. Clive Cookson, Mr. R. Kaye Gray, Mr. Summers Hunter, Dr. R. S. Hutton, Mr. E. Mills, Mr. J. T. Milton, Mr. G. H. Nisbett, Mr. E. Ristori, Mr. A. E. Seaton, Mr. Cecil H. Wilson, Professor T. Turner, and Mr. W. H. Johnson.

Sir Gerard Muntz, the new President, then delivered his inaugural address. The reading and discussion of papers was afterwards proceeded with. Abstracts of some of the papers are presented herewith:—

The Properties and Constitution of Copper-Arsenic Alloys.

The above Paper, by Messrs. Guy D. Bengough, M.A., and B. P. Hill, M.Sc., is divided into two parts; the first deals with the mechanical properties of the alloys of industrial importance, the second with their chemical constitution. In the first part the authors begin by stating the most important purposes for which these alloys are used, namely, for locomotive parts and for dynamo brushes. The reasons for using an arsenic alloy instead of pure copper are, firstly, to secure greater strength and rigidity, particularly at high temperatures; and, secondly, to secure an alloy that shall resist the action of flames—that is, of gases at high temperatures. The working properties of copper are not interfered with, at least to any great extent, by small quantities of arsenic, but the fact that even small percentages seriously lower its conductivity prevents the use of these alloys for electrical purposes. The proportion of arsenic that can be usefully employed for increasing the strength of copper has been generally considered to be much less than 1 per cent., and it has been supposed that beyond this proportion the alloys tend to be brittle. Within the above limit as a maximum, however, very different opinions are held both by engineers and metallurgists. Platten quotes the following as typical of the amounts of arsenic called for by various engineers:—(*a*) Not to exceed 2 per cent.; (*b*) must be present in proportions between 0.25 and 0.4 per cent.; (*c*) must be present in proportions between 0.35 and 0.55 per cent.; (*d*) must not be above 0.15 per cent. Other engineers prefer to exclude arsenic altogether for all purposes, and call for "best select" copper, *i.e.*, one of the purest forms of commercial copper, usually containing only traces of arsenic. In view of the small number of published experimental results one of the authors decided to investigate this matter in a more detailed manner, and, after consultation with Sir Gerard Muntz as a manufacturer of these alloys, sketched out a research which might reasonably be expected to throw some light on the following questions:—(1) What is the best proportion of arsenic to use in these alloys? (2) What is the effect of heat treatment on them? (3) What is the effect of heating them in a reducing atmosphere? For this purpose five 1-in. round copper bars containing amounts of arsenic varying from 0.04 per cent. to 1.94 per cent. arsenic were prepared under ordinary industrial conditions by the Muntz Metal Company, and were thoroughly tested by the authors in three conditions, namely:—(1) As rolled; (2) after being heated for various lengths of time in an oxidising atmosphere; (3) after being heated for similar times in a reducing atmosphere. The reducing gases used in the third set of tests were coal gas, hydrogen and carbon monoxide. Since these gases are liable to come in contact with the copper-arsenic alloys used in practice in locomotive fire-box construction, it was thought that an interesting light might be obtained on the causes of deterioration and failure of the alloys in practice. Upwards of a hundred tensile tests were made to ascertain the exact conditions under which the mechanical properties of bars containing 0.04, 0.26, 0.75, 0.94, and 1.94 per cent. of arsenic, respectively, were spoilt by contact with gases at high temperatures. Briefly, these conditions were found to be:—

(*a*) Alloys containing between 0.04 and 1.0 per cent. of arsenic were ruined by the action of reducing gases for three hours at 700 degrees C.; in some cases a temperature as low as 600 degrees C. was sufficient.

(*b*) Similar alloys were not harmed by identical treatment in an oxidising atmosphere, nor when the temperature was raised to 900 degrees C.

(c) Alloys containing 1.9 per cent. of arsenic were not harmed by treatment in either an oxidising or a reducing atmosphere.

With regard to the best percentages of arsenic to use in these alloys, the authors found that the alloying metal when present in quantities less than 2 per cent. tends to increase slightly the tensile strength and the elongation of their alloys. They also consider that the homogeneity and the resistance to the action of reducing gases increase with increased percentage of arsenic up to 2 per cent. The authors describe a series of experiments carried out to elucidate the *modus operandi* of the reducing gases in spoiling the alloys, and put forward tentative suggestions as to the means which might be taken to produce bars which would resist the action of reducing gases.

In the second part of the Paper the authors describe the work undertaken to elucidate the constitution of these alloys, and give a diagram illustrating it under certain defined conditions. They confirm the existence of the compounds Cu_3As, and Cu_5As_2, already proposed by Friedrich, and deny the existence of the compound Cu_2As, proposed by Hiorns.

In the course of the discussion on the paper, PROFESSOR HUNTINGTON, while admitting the value of the work done, challenged the statement that the presence of arsenic gave copper good working properties at high temperatures. His experience was that arsenic was very detrimental to copper at high temperatures. Nor was Mr. Bengough's claim as to the effect of reducing gases quite tenable. He had used electrolytic copper with 0.5 per cent. of arsenic.

DR. WALTER ROSENHAIN said that the International Committee on Copper Specifications, of which he was a member, had carefully considered the question of arsenic in copper. Both the French and the Germans were prepared to accept arsenic in locomotive fire-box plates. As regarded raising the limit of arsenic in the specification on the strength of the experiments described in the Paper, he held the view that it would be necessary to obtain further experimental results before making any recommendation in that sense. The question of bending tests had been referred to, but it would be necessary to know something about fatigue and shock resistance before raising the limit of arsenic. At the same time, the results exhibited in the Paper, as far as they went, tended to remove the existing prejudice against high arsenic.

MR. RHEAD reminded members that arsenic alloys were seriously corroded by gases containing chlorine, and this was frequently present in gases from coal fires. In that case a highly volatile chloride of arsenic was formed, and this laid the metal open to serious attack by the other constituents of the gases.

The Analysis of Aluminium and its Alloys.

In this Paper, by MESSRS. R. SELIGMAN, Ph.Nat.D., and F. J. WILLMOTT, the authors state that the bulk of the aluminium of commerce contains as impurities silicon, iron and sodium, together with minute traces of carbon, oxygen and nitrogen, which have scarcely been determined with satisfactory accuracy. The products of some factories also regularly carry small amounts of copper, derived, no doubt, from certain parts of the furnace equipment used in the manufacture of the metal. In the following table (I.) a few characteristic analyses are given, which show the proportions in which these impurities usually occur in commercial aluminium. It will be seen that the relations between the chief ingredients vary in the products of various factories, although the total amount does not differ appreciably:—

TABLE I.

	Extra Pure Metal	Ordinary American	Ordinary English	Ordinary French	Low Grade
Silicon ..	0·20	0·4	0·3	0·4	0·7
Iron ...	0·15	0.35	0·4	0·3	0·6
Sodium ...	0·02	...	0·01	...	0·06
Copper ...	nil	0·1	nil	nil	nil

The statement of Echevarri* that only 0.003 per cent. of sodium is found in English metal must, the authors think, be due to an error. They have never come across metal containing so small an amount. With regard to carbon, nitrogen, and oxygen, they have no reliable data. Moissan found as much as 0.41 per cent. of carbon in American metal in 1898, whereas Dr. Caspari found not more than 0.01 per cent. in English metal in 1907, and sometimes none at all. Of nitrogen they have not met with more than 0.001 per cent., whereas Dr. Caspari found as much as 0.0055 per cent. The only data available as to the amount of oxygen in aluminium are contained in an article by Kohn-Abrest,† who gives about 2.3 per cent. as the amount in some samples of aluminium powder which he was examining. In other forms of the metal, such as sheets, bars, or castings, which present far less surface, the proportion of oxygen must be very much smaller than this. On the other hand, metal which has been seriously overheated may doubtless contain appreciable quantities.

Owing to the impossibility of estimating the aluminium itself with sufficient accuracy, it is customary to determine all the impurities and to calculate the purity of the metal from the figures so obtained. In most cases, only those impurities present in appreciable quantities are estimated, a course which has been fostered by the general ignorance of the influence of the minute quantities of the ingredients thus ignored on the properties of the metal. It is hoped that information will shortly be forthcoming as to the effect of these materials on the metal, so that the methods will have to be modified in this respect.

A detailed description is given of methods of estimating silicon in its various forms, iron and sodium, together with figures indicating the accuracy of the various determinations. The alloys of aluminium in common use contain, in addition to the impurities cited above, copper, zinc, nickel and magnesium, and as an additional impurity, lead. Alloys containing tin are met with in the form of solders or soldered joints. The methods which the authors use for determining these ingredients are described. Occasionally manganese, titanium and tungsten have to be dealt with, and the determination of these elements is briefly referred to. The authors are of the opinion that the closer study to which these alloys are being submitted will enhance their importance and promote their wider introduction.

A Contribution to the Study of Phosphor Bronze.

In this Paper, by MESSRS. O. F. HUDSON, M.Sc., and E. F. LAW, A.R.S.M., the object of the authors' work is to indicate the relation between the mechanical and other properties of the copper-tin-phosphorus alloys and their constitution and structure. Copper and phosphorus combine with the formation of a definite phosphide of copper which forms with copper

* "Journal of the Institute of Metals," 1909, No. I.
† "Bulletin of the Société Chimique," 1909, vol. iv.

a binary eutectic, and a ternary eutectic with copper and the compound Cu_3Sn. With less than 4.5 per cent. of tin the slowly cooled alloys consist of copper holding in solution the tin and, perhaps, a small amount of phosphorus, and of copper phosphide in rather large but fairly uniformly distributed masses, there being no sign of the typical eutectic structure. With more than 4.5 per cent. of tin the ternary eutectic, having the composition 81 per cent. copper, 14.2 per cent. tin, and 4.8 per cent. phosphorus, and a melting point of 620 degrees C., makes its appearance. A diagram is given showing the constitution of all the alloys containing up to about 25 per cent. of tin.

The authors remark that the significance of the results is apparent when the relation between the constitution and the widely varying mechanical properties of the alloys which are known collectively as phosphor bronzes, are considered. It may be recalled that the commercial phosphor bronzes may be classified according to their mechanical properties into two groups:—(1) The malleable phosphor bronzes, which are used for various purposes in the form of plate, sheet, rod and wire; and (2) the cast phosphor bronzes which are used in cases where a metal is required to resist wear and reduce friction, such as bearings, gear-wheels, worm-gearing, slide-valves, etc. The bronzes in which phosphorus is added in small quantities and merely plays the part of a deoxidiser are not considered, as they are outside the scope of the present Paper. The malleable phosphor bronzes are those in which the quantities of both tin and phosphorus are relatively small; that is to say, in quantities insufficient to form the ternary eutectic. In actual practice the quantities present will, of course, depend to some extent on the degree of malleability and ductility required, but the upper limits may be taken as 6 per cent. of tin and 0.3 per cent. of phosphorus. In his Paper on the phosphor bronzes, Mr. Philip draws attention to an alloy possessing approximately this composition (6.5 per cent. tin and 0.32 per cent. phosphorus), which was used for braiding electric cables, and which, he says, two or three makers declared could not be manufactured. Now, from a study of the constitution of these alloys it will be seen that their malleability is due to two causes. In the first place the solubility of phosphide of copper due to the annealing which this class of alloy necessarily undergoes, gives rise to a homogeneous product consisting of a single solid solution. Secondly, the presence of tin plays a part in maintaining the malleability of the alloy which is of considerable interest from a metallurgical point of view. As has already been pointed out, even if phosphorus is present in sufficient quantity to form free phosphide of copper the presence of tin hinders the formation of the phosphide eutectic, and instead of separating out between the crystals of the copper, or in large masses, the phosphide occurs in small, more or less rounded particles, which are evenly distributed throughout the mass of the alloy. A structure of this type gives the maximum degree of malleability possible in an alloy composed of more than one constitutent. The influence of tin on the mechanical properties is shown by the following tests. Both samples were turned down from cast bars which had had no work put upon them.

Analysis.			Breaking Load. Tons per square inch.	Yield Point. Tons per square inch.	Elongation per Cent. on 2 inches.
Cu.	Sn.	P.			
99.52	0.00	0.48	3.8	3.0	3.5
94.65	5.00	0.35	14.5	7.1	17.5

As regards the cast phosphor bronzes in which the properties aimed at are low co-efficient of friction, resistance to wear, and strength rather than malleability, here again the composition naturally depends within certain limits on the use to which the alloy is to be put, but the upper limits may be taken as 12 per cent. of tin and 1.5 per cent. of phosphorus. These alloys possess the essential structure of a good bearing metal, viz., particles of a hard constituent (the ternary eutectic which is often accompanied by free phosphide) embedded in a softer matrix. The ternary eutectic is intensely hard and, moreover, is not easily crushed, so that the softer matrix is soon worn down, leaving the hard eutectic standing in relief, with the result that the load is carried by these hard particles, thus giving the maximum resistance to wear with a minimum of surface exposed to friction.

With regard to the phosphor bronzes containing lead, which are frequently used as bearing metals, the constitution of these alloys is exactly the same as the other phosphor bronzes, except that the lead, which does not alloy with the copper, separates out in the form of minute globules evenly distributed throughout the mass. In these alloys the lead probably plays the part of a lubricant, while at the same time it increases the plasticity.

The Paper includes notes on the examination and analysis of the phosphor bronzes, and is illustrated by a number of photo-micrographs illustrating the structure of the alloys.

Discussion.

Mr. A. Philip was of opinion that the evidence of a triple alloy of copper, phosphorus, and tin, produced by the authors of the Paper, was insufficient.

Dr. Rosenhain agreed that the evidence adduced in the paper did not adequately support the conclusions stated. Additional facts were needed, and it would be a valuable contribution to the subject if the authors would place full details of the work carried out before the Institute.

Mr. Spence Thomas discussed the matter from the point of view of a user of phosphor-bronze. One expected considerably more from phosphor-bronze than from ordinary brass bearings, and he hoped that the co-operation between manufacturers and scientists, which was one of the chief aims of the Institute, would enable the maker to give a guarantee of longer life. His experience with bearings in hot mills was that the life of the bearing under quite similar conditions of service ranged between one month and fifteen months. That was too great a difference, and the maker had to get over that.

Prof. Thomas Turner said that there was a great difference in the various varieties of phosphor bronze, as much as in cast iron, wrought iron, and steel. These very considerable differences in the results in service might result in the first place from the variation in the constituents, and in the second place by the heat treatment. Whatever might be thought as to the existence of a triple alloy, there was a constituent which disappeared and re-appeared according to the heat treatment, and that fact had a most important bearing on the matter.

Mr. Law, in replying on the discussion, said that the trouble referred to by Mr. Spence Thomas might be explained by the fact that the triple eutectic had a low melting point, 620 degrees C., and that the bearing could not therefore withstand the high temperature of the hot mill. He would like Mr. Thomas to tell him what had been the behaviour of phosphor-bronze bearings for cold mills.

Mr. Spence Thomas said he had used such bearings for cold mills, and their life was sometimes longer and sometimes shorter than in the hot mills. His experience in that direction was negative as to definite results.

Moulding Box for a Lathe Gantry.

By T. W.

The moulding box here described will interest those engaged in the manufacture of machine tools. Fig. 1 illustrates the pattern of a lathe pantry for an Anglo-American lathe gap-bed. Fig. 2 shows the sectional end view of same. It will be readily seen that a considerable saving is effected by the box, Fig. 3, over the ordinary method of bedding in the floor and making a sloped joint over the gap-end.

Where a large number of these castings is required, it more than pays the founder to lay out a little capital in the making of a few good boxes, thereby ensuring better castings and less labour. Fig. 3 illustrates the complete box closed, as it stands when rammed up and ready for casting. Fig. 4 depicts the end of same, showing hinges

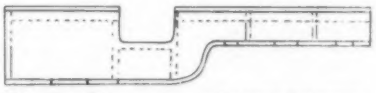


FIG. 1.—PATTERN OF A LATHE GANTRY.

FIG. 2.—SECTIONAL END VIEW.

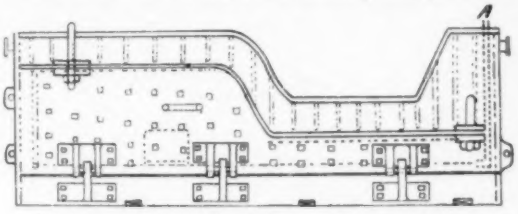


FIG. 3.—BOX FOR MOULDING A LATHE GANTRY.

and bolting lugs by which the two sides are bolted together, also the frames which are bolted by ½-in. bolts to sides of box for carrying the body of sand. Fig. 5 shows the end of box, illustrating how the sides are lifted away for the purpose of finishing.

Method of Moulding.

The box is stripped as shown at Fig. 5; then the bottom box A is filled with old sand to within 1½ in. from the joint B, and carefully rammed to ensure a good level surface free from swells and strains. The facing sand is then laid on to the width of the pattern face and the whole again rammed until level with the joint B. Venting is thoroughly done, and the box is then strickled off lengthwise and sleeked with the trowel. Two straight edges, long enough to go the full length of the box and lay flat between the uprights C at ends of box, Fig. 5, are procured, and laid the same width apart, as the width of the print (A, Fig. 2). It is then necessary to strickle out between the straight edges to the depth of the print, when the bed will be ready to receive the pattern. If the bottom box has been carefully made and double camber allowed in the pattern no trouble will be experienced so far as cambering is concerned. It is next necessary to ram up underneath the gap-piece, inserting wedge-shaped rams to connect between the gap at the end of the sheaves. This ensures an even flow of the metal when rising during the process of pouring; if these runners are omitted there is the liability of cold shot or cold seams, which look unsightly, and at the same time jeopardise the strength of the casting. The sides D, Fig. 5, are then lowered down into position, bolted at the ends and rammed up in the usual way. If the carrying frames have been carefully designed no gaggers (or hookers as they are termed in the South), are required for binding the sand. This joint is then made in the usual way, and the top box placed on in position and rammed up. The runner peg is described in Fig. 3 at the end of the box. When the top box is lifted off and placed on trestles, a channel is made about 3 in. from the face of the pattern and about 1 in. deep. When water has been placed around the edge of the pattern the mould is vented along the channel about 2 in. apart for the full length. The pattern is then drawn, and any loose edge on the joint edge is tightened down by placing a thin strip along the inside and sleeking with the trowel. The ends of the box are next unbolted, the sides lifted back on the hinges and placed on props, as shown in Fig. 5. As a rule, there is little or no finishing to do at the sides, and what there is to do is in the best of posiions for being finished properly. It often occurs that there is a name to be placed along the side of gantry. This is best inserted in a core, but sometimes a name-plate is merely stamped in. However, be that as it may, it is an easy matter when the gantry is made in this manner. When the prints have been drawn from the sand the cores are placed in position, the sides are brought into position, the top box placed on, the ends bolted, the runner bush made, and it is ready for pouring. The writer has made castings 14 ft. long in this type of box, and has effected a considerable saving of time and labour over the old methods.

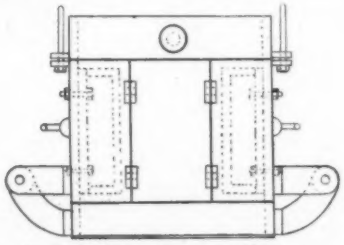


FIG. 4.—END VIEW OF BOX.

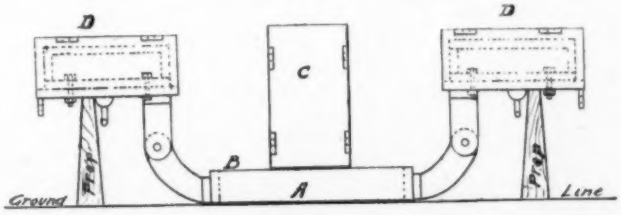


FIG. 5.—SHOWING BOX SIDES LIFTED AWAY FOR FINISHING.

The Nature and Uses of Ferro-Silicon.

A report dealing mainly with the possible dangers arising from the transport and storage of ferro-silicon was issued last month by the Local Government Board. The report is written by Dr. S. Monckton Copeman, Mr. S. R. Bennett, one of H.M. Inspectors of Factories, and Dr. H. Wilson Hake, F.I.C., and is of a most comprehensive character, a vast amount of useful information having been collected of the subject of ferro-silicon generally. The enquiry embraced an extended investigation in Sheffield and on the Continent, as well as complete chemical and microscopical researches.

Summary of Conclusions.

As a result of the investigation, Dr. Copeman states the following conclusions:—

Numerous accidents, fatal and otherwise, have been caused within the last few years by the escape of poisonous and explosive gases from consignments of ferro-silicon, which, in every instance, have been found to consist of so-called high-grade ferro-silicon, produced in the electric furnace.

These accidents, for the most part, have occurred during transport of the ferro-silicon by water, whether in sea-going vessels or in barges and canal boats plying on inland waters.

These accidents have occurred in various countries and on vessels of different nationalities, while the ferro-silicon carried has, in almost every instance, been the product of a different manufactory.

Ferro-silicon, especially of grades containing from 40 per cent. to 60 per cent. of silicon, is invariably found to evolve considerable quantities of phosphoretted hydrogen gas, and, in less amount, of arseniuretted hydrogen, both of which are of a highly poisonous nature. A certain amount of the gas evolved is present, as such, in the alloy, being "occluded" in minute spaces with which its substance is often permeated.

As the result of careful investigation, it has been shown that certain grades of ferro-silicon notably such as contain about 33 per cent., 50 per cent., and 60 per cent of silicon (corresponding possibly to the formulæ, FeSi, $FeSi_2$, and $FeSi_3$, respectively)—even when manufactured from fairly pure constituents, are both brittle and liable to disintegrate spontaneously, this latter characteristic being apt to be specially marked in the case of the 50 per cent. grade.

In the event of disintegration occurring, the amount of surface exposed will, obviously, be greater than if the mass were solid.

Evolution of poisonous gases is greatly increased by the action of moisture, or of moist air, under the influence of which phosphoretted hydrogen is generated from calcium phosphide, which, in turn, is formed, in large part at any rate, from the calcium phosphate present in anthracite and quartz, at the high temperature of the electric furnace. If spontaneous disintegration of the alloy also occurs, much larger quantities of gas would be given off from such friable and unstable material, other conditions being equal. The greater or less tendency of a given sample to evolve poisonous gases, and even a rough estimate of their probable amount, may be arrived at by the use of test papers prepared with silver nitrate.

There is no evidence that low-grade ferro-silicon (10 to 15 per cent.), produced in the blast furnace, has ever given rise to accidents of similar character to those known to have been caused by the high-grade electrically-produced alloy. Blast-furnace ferro-silicon does not evolve poisonous gases even in presence of moisture.

As regards ferro-silicon produced in the electric furnace, the evidence available goes to show that certain percentage grades are practically quite innocuous. This statement applies to grades of alloy of a silicon content up to and including 30 per cent., and probably also, though in considerably less degree, to those of 70 per cent. and over.

In view of the fact that the use of ferro-silicon of grades ranging between 30 per cent. and 70 per cent. apparently is not essential in metallurgical operations, with the possible exception of basic steel manufacture, it will be advisable that the production of this alloy of grades ranging between these percentages should be discontinued in the future.

The proprietors of iron and steel works making use of ferro-silicon will assist in the protection of their workpeople, and at the same time act for the public benefit, by restricting their orders to grades of this material, either not exceeding 30 per cent., or of 70 per cent. and upwards, according to the special nature of their requirements.

But as, pending international agreement on the question, intermediate percentages of ferro-silicon will doubtless continue to be manufactured and sold, the issue, by the Board of Trade, of special regulations will be necessary in order to obviate, so far as may be possible, chance of further accidents during the transport of this substance.

Inter alia, these regulations should require a declaration of the nature, percentage, date of manufacture, and place of origin of any such consignment.

Suggested Regulations.

The precautionary measures proposed in connection with the storage and transport of ferro-silicon are as follows:—

1. Ferro-silicon should not be sent out from the works immediately after manufacture, but, after being broken up into pieces of the size in which it is usually sold, should be stored under cover, but exposed to the air as completely as possible, for at least a month before being despatched from the works.

2. Manufacturers should be required to mark in bold letters each barrel or other parcel of ferro-silicon with the name and percentage grade (certified by chemical analysis) of the material; the name of the works where it is produced; the date of manufacture; and date of despatch.

3. The carriage of ferro-silicon on vessels carrying passengers should be prohibited. When carried on cargo boats it should, if circumstances permit, be stored on deck. If it be considered necessary to store it elsewhere, the place of storage should be capable of being adequately ventilated, and such place of storage should be cut off by air-tight bulkheads from the quarters occupied by the crew of the vessel.

4. This regulation should apply to the transport of ferro-silicon on river or canal barges as well as on sea-going vessels.

5. Storage places at docks or at works where ferro-silicon is used should have provision for free access of air, and should be situated at a distance from work-rooms, mess-rooms, offices, etc.

Classification of Ferro-Silicon.

Dr. Wilson Hake, as a result of his researches, classifies ferro-silicon as follows:—

Class I.—10 to 30 per cent. silicon, containing practically no poisonous impurities and not liable to spontaneous disintegration.

Class II.—70 to 96 per cent. silicon, not entirely free from poisonous impurities, but also not liable to disintegrate spontaneously.

Class III.—35 to 60 per cent. silicon, containing, in most instances, a considerable proportion of poisonous impurities, and, in addition, being more or less liable to spontaneous disintegration.

The Present and Future Supply.

Notwithstanding, however, that practically all the chief shipping companies have determined, under existing circumstances, to discontinue acceptance of consignments of ferro-silicon from abroad, a certain amount of the material continues to reach this country, owing to the fact that certain owners, in order to obtain trade, are willing to accept possible risk. As a consequence, what business remains has been transferred from East Coast to West Coast ports, and, at present, practically all consignments, comparatively small in amount, from France, Austria, and Italy to this country, are being shipped from Tréport to Manchester. From Sweden, also, the traffic has now been diverted from Hull to Manchester, an alteration of route which is stated to have involved considerable pecuniary loss. At this latter port the cargoes are discharged into "flats," in which they are taken back to Liverpool, and from thence conveyed to Sheffield and elsewhere by rail. But owing to the fact that some, at any rate, of the high-percentage ferro-silicon still coming from abroad is consigned under the name of iron ore or other similar designation, it is practically impossible for the port authorities to afford any reliable statistics as to the actual amount of this material imported.

There can, however, be no doubt that agents' and manufacturers' stocks are becoming depleted, and that, in consequence, especially as no electrically-produced ferro-silicon is being produced in this country, considerable anxiety exists as to how future needs for this material are to be met.

The Climax Cinder Mill.

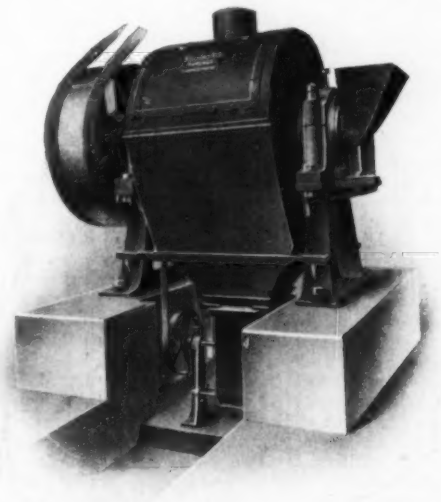
It is not generally realised what a high percentage of metal is contained in cupola slag or cinder, and in ashes and skimmings in the brass foundry. It is a fact, however, that cupola slag frequently contains 15 to 20 per cent. of iron, and brass furnace ashes and ladle skimmings frequently contain from 25 to 30 per cent. of metal. The importance of recovering this valuable material, therefore, will be apparent to all foundrymen. The cinder mill illustrated herewith has been designed for recovering metal from cupola refuse, brass ashes, skimmings, sweepings, etc., in iron and brass foundries. It is entirely automatic in action and requires no water, the slag being ground dry. All the dust produced is carried away to a dust chamber, and not allowed to pollute the air.

The machine consists of a ball grinding mill, into which the material is fed through the charging hopper shown on illustration. Enclosing the grinding mill there is a scouring drum by means of which the cinder is automatically separated from the metal, the latter passing to the outlet on the side of the machine opposite the hopper, the slag flour passing through an octagonal sieve and thence to the bottom outlet, where a magnetic separator will remove any fine particles of iron still remaining in it.

The inside of the grinding drum is of steel, and all parts subject to wear are made so as to be readily renewable. The driving gear and grinding drum are fitted with easily removable dust-proof casings. The sieves are all made detachable, and are readily renewed.

The machine is set in motion and material fed into the hopper until the knocking of the balls is only faintly but distinctly heard. The machine is then allowed to run, and the material is fed into the hopper at intervals of from 10 to 15 minutes. After some time, depending upon the quantity of iron in the slag, the machine becomes fully charged with iron and is then stopped and run in the opposite direction and the iron thereby discharged.

The magnetic separator delivers the slag flour on one side and the fine iron particles on the other, and is automatically stopped when the grinding mill is emptying. When the mill is being used for grinding coal dust, moulding sand or other materials, the magnetic separator is not run and the ground material does not pass through it. When the mill is used for grinding broken crucibles, brass ashes, etc., screens with smaller meshes, provided with the mill, are used, and the magnetic separator is placed



THE CLIMAX CINDER MILL WITH MAGNETIC SEPARATOR.

under the hollow axle of the mill so that any iron is separated from the brass as the recovered metal leaves the mill.

The machine is entirely self-contained and can be located in any convenient position.

The makers are Messrs. J. W. Jackman & Company, Limited, Caxton House, Westminster, S.W.

Alloys of Copper, Aluminium and Manganese.

On Friday, January 21st, before the Institution of Mechanical Engineers, there was read an important Paper prepared by Dr. W. Rosenhain and Mr. F. C. A. H. Lantsberry, of the National Physical Laboratory, at Teddington, and embodying the "Ninth Report to the Alloys Research Committee; on the Properties of some Alloys of Copper, Aluminium and Manganese." The Paper, which extends to 175 pages and is illustrated by 16 plates and 45 Figs. in the letterpress, is too long to be dealt with *in extenso* in our columns, but an abstract of the authors' remarks introductory to the subject and a summary of their conclusions are here presented.

The authors state that in the Eighth Report to the Alloys Research Committee Messrs. Carpenter and Edwards have described an extensive research into the properties of the alloys of copper and aluminium; to quote their own words they have carried the research to a point "where the way is clear for investigating the influence of a third metal." The present Report deals only with the properties of some of the more interesting alloys which result from the addition of manganese to alloys of copper and aluminium. At the outset the authors would, however, point out that the present research does not claim to deal exhaustively with this group of alloys, particularly as regards their constitution. The choice of manganese as the first of the metals whose influence on the alloys was to be investigated rests in great part on the recommendation of the Alloys Research Committee, whose decision was arrived at from a consideration of the suggestions of those interested in the copper-aluminium alloys. This choice is also to be justified on purely metallurgical grounds. The plan which has been followed is that of first determining some of the more prominent features of the properties of the ternary alloys by means of what may be termed "exploratory" meltings made on a comparatively small scale, with the object of ascertaining approximately the limits of usefulness of the range of alloys, and also of choosing a certain number of the most promising members of the series for closer and more exhaustive study. A series of such exploratory meltings has therefore been carried out for a range of ternary alloys corresponding to each of the two ranges of useful alloys of the binary series.

The authors have endeavoured to explore that corner of the ternary system which embraces alloys containing less than 10 per cent. of manganese and less than 11 per cent. of aluminium with sufficient completeness to arrive at some estimate of the true constitution of this range. All the problems presented by this limited range of alloys have by no means been solved, but the data given will, it is hoped, be sufficient to guide any practical workers who may wish to utilise these alloys.

As regards the mechanical properties of the alloys studied, care has been taken to render the new data as closely comparable as possible with the mass of data contained in the Eighth Report, and frequent comparisons between the results of tests on the ternary alloys and the results contained in the Eighth Report have been given in the text.

With regard to the general results obtained in the course of the present investigation, much must depend upon the point of view from which the properties of the alloys are considered. As regards the heavy alloys, viz., those whose principal ingredient is copper, the authors regard certain results as remarkable. As compared with the best of the binary alloys of copper and aluminium, the ternary alloys, which have been closely studied, present certain advantages, chiefly consisting in a higher "yield-point" (in so far as this term is applicable to such alloys at all), a slightly higher ultimate stress, and an undiminished ductility.

A very remarkable result, and one which, if borne out by practical experience, should render these alloys of considerable value in several directions, is that relating to their resistance to abrasion. While the alloys are found to machine very readily and to be capable of taking a highly-finished surface, they present a resistance to abrasion which, under the test applied by Dr. Stanton's machine, places them in this respect considerably above ordinary tool steel. Under loads which would immediately indent and destroy any ordinary bearing metal, rings of these alloys have been run for a large number of revolutions with only an inappreciable amount of abrasion. As regards resistance to corrosion, both in fresh and sea water, the ternary alloys which have been investigated appear to be at least equal to the copper-aluminium alloys and in some cases even show a slight superiority.

As regards the light alloys, consisting principally of aluminium, the results of the present investigation are not so favourable. An interesting feature of the results obtained with these alloys is the determination of the very great extent to which the properties of the metal depend, in the case of castings, on the temperature at which the metal is poured into the moulds.

General Summary.

Part I.

Alloys Rich in Copper.—The mechanical properties of the alloys of copper and aluminium with manganese lying within the limits of an aluminium content of 11 per cent. and a manganese content of 10 per cent. have been explored in the first instance by a series of twenty-two "exploratory" meltings of approximately 20 lbs. each, tensile tests of sand- and chill-castings of each of these alloys being made. The general inference drawn from the results is that the effect of manganese is in most respects similar to that of aluminium itself, but that while larger additions of manganese render the alloy brittle and weak, the first effects of adding small quantities of manganese are to stiffen the alloys, *i.e.*, to raise both their yield-points and ultimate strengths without diminishing their ductility. On the basis of this conclusion nine alloys, ranging in manganese content from ½ per cent. to 5 per cent., and in aluminium content from 7 to 10 per cent., were selected for preparation on a larger scale and for more complete investigation. Subsequently only three of these were found sufficiently promising to warrant complete study, including kinetic tests. Tensile tests on these nine alloys in the form of sand-castings, chill-castings, rolled bars of various sizes and cold-drawn bars, gave a series of interesting results, several of the alloys proving themselves decidedly superior to any of the binary alloys of copper and aluminium. Thus in the case of sand-castings, the alloy No. 2 containing approximately 10 per cent. of aluminium and 1 per cent. of manganese, shows a yield-point of 14 tons per square inch, an ultimate stress of 35.76 tons per square inch, and an elongation of 22.5 per cent. on 2 in., as compared with the best of the binary alloys, described in the Eighth Report (No. 13), which gave a yield-point of 11.3 tons, an ultimate stress of 31.7 tons and 21.7 per cent. elongation on 2 in. in the form of sand-

castings; again, the alloy No. 6 of the present series, containing approximately 9 per cent. of aluminium and 2 per cent. of manganese, gives almost exactly the same yield-point and ultimate stress as the 10 per cent. copper-aluminium alloy, but shows 46 per cent. elongation on 2 in. as compared with 36 per cent. In the form of rolled bars $\frac{13}{16}$ in. in diameter, the best of the ternary alloys attain an ultimate stress of nearly 43 tons per square inch, with a yield-point of 23 tons and an extension of 22.5 per cent., while another alloy with a yield-point of 19 tons and an ultimate strength of 40.5 tons, shows an elongation of 40 per cent. on 2 in. The results of these more detailed tensile tests lead to the definite conclusion that the effect of the addition of manganese in relatively small quantities to alloys of copper and aluminium is to stiffen the alloy, *i.e.*, to raise its yield-point and its ultimate strength without reducing its ductility to a corresponding extent. The similarity of properties between small chill-castings and hot-rolled bars, found by Messrs. Carpenter and Edwards, in the case of the 10 per cent. copper-aluminium alloy, is not, however, reproduced in the present series of ternary alloys.

Hardness tests, by both the Brinell ball method and by the Shore "scleroscope," have been made on the nine selected alloys, and their hardness numbers are found to differ only very slightly (Brinell number varies from 170 to 199), a result which is somewhat surprising in view of the comparatively wide variations of tensile strength which exist between the different alloys.

The torsion tests of these nine alloys yield results generally consistent with those of the tensile tests, but it is notable that alloy No. 9, containing approximately 8 per cent. of aluminium and 5 per cent. manganese, gives both the highest maximum strength (in torsion) and the largest angle of twist—a result which is remarkable since in most groups of alloys the angle of twist diminishes rapidly as the maximum strength increases. The ratio of maximum stresses as found by torsion to those found by tension tests varies somewhat, from 0.75 to 0.90, but never reaches or exceeds unity, as is the case with a number of the binary alloys of copper and aluminium.

The whole of the nine selected alloys were, by the kindness of Professor Arnold, tested in the "alternating stress" machine at Sheffield. The results show some considerable variations, which cannot, however, be ascribed to any lack of uniformity in the material, but the mean results indicate that while none of the present series of ternary alloys are quite as good under this test as the alloy No. 9 of the Eighth Report, yet in view of the much higher tensile strengths of the present alloys their behaviour under Professor Arnold's test is remarkably good.

Three of the alloys, viz., No. 2, containing approximately 10 per cent. aluminium and 1 per cent. manganese, No. 3, containing 10 per cent. aluminium and 2 per cent. manganese, and No. 6 containing approximately 9 per cent. of aluminium and 3 per cent. of manganese, were chosen for further investigation. This included a determination of the elastic limit and elastic modulus, the autographic stress-strain diagram, the investigation of the effect of cold drawing on the elastic modulus of the alloys, tensile tests at high temperatures (up to 450 degrees C.), a series of dynamic tests carried out by Dr. T. Stanton, an examination of the effects of heat-treatment, and fresh- and sea-water corrosion tests.

The elastic limits, as observed by the Ewing extensometer, were found to be approximately 8, 9 and 12 tons per square inch for the three alloys in numerical order, while the elastic modulus ranged from 13.6×10^6 lbs. per square inch in No. 2 to 14.9×10^6 in No. 6. It was found that cold-drawing does not appreciably alter the modulus, although the elastic limit is, of course, very considerably raised. In view of the fact that the elastic limits found by the extensometer are lower than those derived from the alternating-stress tests, the autnors conclude that the elastic limits of the alloys in the condition as examined were in some way artificially depressed, and that normalised material would probably yield higher values. The low values of the elastic moduli as compared with those of steel are important as affecting the possible utility of these alloys in high-speed machinery, etc.

The autographic stress strain diagram shows considerably lower yield-points than those obtained by the use of dividers on tests of 2 in. specimens; for a discussion of this discrepancy the reader is referred to page 80 of the main Report.

Tensile tests at high temperatures were carried out in an apparatus very similar to that described in the discussion of the Eighth Report, and the results obtained are very similar to those found for the 10 per cent. copper-aluminium alloy. The tensile strength appears to be well maintained up to about 300 degrees C., but then falls off rapidly. The hope that the addition of manganese would materially improve the alloys in this respect has not been entirely verified, but there is some reason for believing that on prolonged exposure to moderately high temperatures the ternary alloys would behave better than the pure copper-aluminiums.

The dynamic tests carried out by Dr. Stanton included alternating stress-tests by direct reversals of stress, single-blow impact tests on the Izod machine and repeated bending-impact tests with two different values of blow. Under the alternating-stress tests the three alloys behave in an almost identical manner and the tests indicate that the safe range of maximum stress is approximately 25 tons per square inch when the rate of reversal approaches 1,000 per minute; when this range is compared with that found for the copper-aluminium alloys of the Eighth Report at a slower rate of alternation, a correction of 10 per cent. must be applied, with the result that a difference of about 1 ton per square inch remains in the calculated safe ranges, the difference being in favour of the pure copper-aluminium alloy (10 per cent.). Under the single-blow impact test, on the other hand, the present alloys show an absorption of from 9.5 to 10.5 foot-pounds for fracture, the figure for the 10 per cent. copper-aluminium alloy being only 4.5. Evidently the influence of manganese makes itself felt in the power of the alloys to resist a sudden shock. Under the repeated bending impact test, with a tup weighing 6.15 lbs.falling through a height of 2.01 in., alloy No. 2 gives the best result, fracturing only after over 900 blows, while No. 6 fails under 600, the alloys under this test giving the same result as that derived from the mean of Professor Arnold's figures. With the lighter tup (4.71 lbs.) and lesser fall (1.01 in.) which are ordinarily used in impact tests on steel, the order of the three alloys is changed; all three, however, require more than 10,000 blows, while the best result yet obtained with Swedish Bessemer steel in the same circumstances is a resistance to 6,000 blows.

Abrasion tests were made on rings of the three alloys in Dr. Stanton's rolling abrasion testing machine, and the alloys were found to offer a most remarkable resistance to abrasion; while rings of rail steel lost 64.5 milligrammes, and a ring of tool steel lost 27 milligrammes, a ring of alloy No. 6 only lost 10 milligrammes, while alloys Nos. 2 and 3 behaved very nearly equally well. If the behaviour of the alloys in practice should bear out these remarkable

results, a field of special usefulness should be open to them, particularly as the alloys machine quite readily.

The effects of both annealing and quenching the alloys at temperatures just above two critical ranges which have been observed on their cooling curves have been studied. Generally speaking, the result of either annealing or quenching from temperatures near 550 degrees C. (1,022 degrees F.) is not very marked, although annealing injures alloys Nos. 2 and 3, while subsequent quenching only restores it partially to its original condition. Alloy No. 6, however, differs from the two others and from many other copper alloys in that annealing at 550 degrees C. does not injure it but rather improves it, so far as sand-cast specimens are concerned. Annealing any of these alloys at temperatures above 800 degrees C. (1,472 degrees F.) is found to injure them very seriously, while quenching them from this higher temperature produces a relatively hard and brittle material which possesses high tensile strength but very little ductility. The alloy No. 3, in the form of rolled bar quenched from 850 degrees C. (1,562 degrees F.), attains a tensile strength of 52 tons per square inch with an elongation of 3.5 per cent. This material shares with the cold-drawn bar of the same alloy the highest tensile strength yet found in these alloys, but the drawn bar has the advantage of possessing a higher elongation (10 per cent.). The "annealing temperatures" of cold-drawn bars were also determined in connection with the study of heat-treatment, and it was found that the hardness due to cold working began to disappear after the alloys had been exposed to a temperature of 550 degrees C.

Fresh- and sea-water corrosion tests were made by exposing samples of the alloys (sand-cast) to the action of fresh- and sea-water in tanks in the laboratory, the alloys being exposed both singly and in contact with mild steel plates. All the alloys exhibit a very marked resistance to corrosion; in fresh water the ternary alloys appear to be decidedly less liable to corrosion than the binary alloys of copper and aluminium; in sea-water, on the other hand, alloy No. 2 appears to lose nearly as much by corrosion as Naval brass; in alloy No. 6, on the other hand, no corrosion whatever was observed. In addition to these laboratory tests, specimens of the alloys are undergoing exposure to the sea at Portsmouth Dockyard. The results of sea exposure corrosion tests on copper-aluminium alloys are presented in an Appendix to the present Report.

Special experiments were made to test the question whether alloys of the type of those here investigated could be prepared from manganese derived from a commercial 80 per cent. ferro-manganese; the results obtained show that if a cupro-ferro-manganese is first prepared and the alloy made from this the results are satisfactory, but that it is not possible to use ferro-manganese directly for the preparation of the copper-rich alloys.

The Constitution of the Alloys.—The work in this direction embodied in the present Report has been confined to an approximate study of the constitution of the ternary alloys containing less than 11 per cent. of aluminium and less than 10 per cent. of manganese. These have been studied by the determination of cooling curves of over 100 alloys, while differential cooling curves and photo-micrographs of a large number have also been prepared; some of these are reproduced in the Report. The results of the investigation, so far as the freezing points of the alloys are concerned, have been embodied in a model of the "liquidus" surface of the alloys over the region named, and the contour lines of this model are reproduced in the Report. While a discussion of the lower arrest points, indicating thermal changes taking place in the alloys after solidification, serves to show that the data as yet available—although very numerous—are not adequate for the solution of the very complex problems involved, a discussion of the correlation of the shape of the "liquidus" surface, the micro-structure and the mechanical properties of the alloys reveals a series of interesting relationships, which serve to clear up the more general questions as to the nature of the alloys. The conclusions arrived at are, briefly, that within the limits of the alloys studied, the constitution of the ternary alloys very closely resembles that of the binary alloys of copper and aluminium; manganese influences the properties of the alloys in a manner somewhat similar to that of aluminium, but at a different rate. In no case does manganese give rise to the formation of a third phase, so that all the alloys consist of either a single solution (the α body) or of two phases, in each of which manganese exists in the form of a solid solution. The compound Cu_3Al appears to be capable of dissolving manganese, and there is no evidence of the formation of a ternary compound. The "valley" or ternary minimum observed in the liquidus surface divides this range of alloys into two classes corresponding to the alloys of copper with aluminium, whose aluminium content places them on the copper side of the minimum in the liquidus, and those on the aluminium side of the minimum, the former being homogeneous and the latter duplex in structure. As regards the effects of annealing and quenching, the ternary alloys show a very strong similarity to the binary alloys.

Part II.

The Alloys Rich in Aluminium.—A preliminary study of the aluminium-manganese series of binary alloys is briefly described, the principal results being that a binary eutectic is found to exist close to the aluminium end of the series, while the alloys on the manganese side of this eutectic contain increasing quantities of the compound Al_3Mn. The existence of this hard, brittle compound at once limits the possible extent to which manganese can be usefully added to alloys consisting principally of aluminium. The study of ternary alloys has therefore been confined to the range containing less than 4 per cent. of either copper or manganese.

The mechanical properties of this range have been studied by means of eight exploratory meltings of which tensile tests on sand- and chill-castings were carried out. The results of these tests, while not very promising in themselves, indicated that two alloys, viz., those containing 2 per cent. of copper and 2 per cent. of manganese, and 3 per cent. of copper and 1 per cent. of manganese, respectively, were worthy of further study. Larger quantities of these alloys were accordingly prepared, and were studied on the same general lines as those followed in the case of the heavy alloys described above. The results obtained by tests on these alloys, prepared in large quantities and under more favourable conditions as regards melting and casting temperatures, led to the conclusion that these alloys are very sensitive to casting temperatures. This was tested subsequently by a special experiment, and it was found that while a chill-casting poured at a mean temperature of 680 degrees C. (1,256 degrees F.) gave a tensile strength of 11.6 tons per square inch with an elongation of 8 per cent. on 2 in., the same metal poured into a similar mould at a mean temperature of 750 degrees C. (1,382 degrees F.) gave a tensile strength of less than 6 tons per square inch and an elongation of only 2 per cent.—both castings being apparently quite sound. The results of tensile tests of sand-castings of the two selected light alloys

compare favourably with those of pure copper-aluminium alloys, and this is still more notable in the case of the chill-castings. The tensile tests of alloy No. 11 (3 per cent. Cu., 1 per cent. Mn) which stand at an ultimate strength of 12 tons per square inch, with an elongation of 13.5 per cent. on 2 in., are among the most remarkable results of the present Report, since they very considerably exceed the results of any of the binary alloys of aluminium with copper. It was hoped that this difference in favour of the ternary alloys would be maintained when the alloys had been rolled into bars $\frac{1}{16}$ in. in diameter, but although the results of tensile tests on these bars are slightly superior to those found in the binary series, the difference is not nearly so important as in the case of the chill-castings; in the form of rolled bars there does not appear to be any advantage in using the ternary alloys as compared with the alloys of aluminium with copper alone. It was further found that the two selected light alloys could not be drawn cold to any considerable extent without drawing hollow, and even the moderate amount of cold working attempted in the case of alloy No. 11 in the process of "drawing and annealing" was found to produce hollowness; alloy No. 10, however, with 2 per cent. of each added metal, stood the process of drawing with annealing in a satisfactory manner. The specific gravities of the alloys have been determined in all the available conditions; they range for alloy No. 10 from 2.71 to 2.80, and for No. 11 from 2.67 to 2.79. In all cases the rolled material is markedly denser than the chill-cast.

The elastic limits and elastic moduli of the two alloys were determined with the Ewing extensometer; the elastic limits are 7.15 tons for both alloys, while the elastic moduli are 10.75×10^6 and 10.4×10^6 respectively. The elastic limits thus determined agree approximately with the values deduced from alternating-stress tests.

Autographic stress-strain diagrams were also taken from the 8-in. specimens used for elastic determination, and gave results which agree to a reasonable extent with the values found by tests on 2 in. specimens.

The dynamic tests carried out on these two light alloys by Dr. Stanton were made at the same time as those already described in the case of heavy alloys. The alternating stress tests gave results which indicate that alloy No. 10 possesses a safe range for alternating stresses of 9.4 tons per square inch, while for alloy No. 11 the range is 8.8 tons per square inch. Under the single-blow impact tests the two alloys absorbed 4.1 and 5.5 foot-pounds at fracture—figures which in view of the relatively low tensile strength of these materials are surprisingly high. Under the repeated bending impact test as applied to the heavy alloys or to steel specimens, these light alloys would have fractured after very few blows; a lower height of drop was accordingly employed (0.71 in. instead of 1.01), and with a tup weighing 4.71 lbs. the alloys fractured after 590 and 672 blows respectively; these data cannot be readily compared with tests on other materials, but may serve as a basis for comparison with other light alloys which may subsequently be tested.

The structure and constitution of the light alloys has been examined by determinations of the cooling curves of all the exploratory heats and also of thirteen additional alloys made in small quantities for this purpose. The alloys all show at least two definite arrest points, while the majority show three, and two even show four such points. The data available and the very narrow range of alloys studied would have rendered the construction of a model of the equilibria unsatisfactory, and the constitution of the alloys is discussed only in general terms on the basis of the observed cooling curves and micro-structures. In these alloys three distinct phases are found; these are a solid solution which is pure or nearly pure aluminium, containing some copper, but practically no manganese in solid solution; the aluminium-copper compound $CuAl_2$ and the aluminium-manganese compound Al_3Mn; the pyrometric evidence appears to indicate that the freezing points of the eutectics formed by each of these compounds in combination with aluminium are affected—in the ternary alloys—by the presence of the other compound in the mother-liquor, while a ternary eutectic of the three phases is probably found in most of these alloys, being, of course, the last body to solidify. The freezing temperature of this ternary eutectic appears to be 522 degrees C. (972 degrees F.). Differential cooling curves of these alloys indicate that there are no thermal changes below the point of final solidification, so that no annealing or quenching experiments were required. The structure of alloys Nos. 10 and 11 is somewhat similar, exhibiting large crystals of the aluminium constituent, surrounded by a eutectic in which traces of the compound Al_3Mn are clearly discernible. The structure of the "hot" rolled bars is somewhat remarkable, showing very marked signs of cold work, and thus indicating that the finishing temperature employed during the rolling of these alloys had been low enough to produce considerable cold working.

As in the case of the heavy alloys, experiments were made to determine whether the use of ferro-manganese is permissible in the production of these alloys. A heat of an alloy of the type of No. 11 was made in which the copper and manganese were introduced in the form of cupro-ferro-manganese previously prepared from ferro-manganese; the resulting alloy contained 0.1 per cent. of iron, and gave results which were only slightly inferior to those of the original alloy No. 11. An alloy of the type of No. 10 was prepared by the use of ferro-manganese direct, the resulting alloy containing 0.52 per cent. of iron, and this alloy gave results appreciably better than those obtained from the original No. 10. It is therefore probable that the introduction of small proportions of iron may materially improve these light alloys.

The suggestion having been made to the authors that alloys of aluminium and manganese might possess a considerable power of resisting the attack of mineral acids, a series of experiments was made in which small blocks of a series of binary alloys of aluminium and manganese were exposed to nitric and sulphuric acid of 10 per cent. and 50 per cent. strengths; the results showed, however, that none of these alloys were even equal to pure aluminium in their acid-resisting properties.

MORDEY, CARNEY & COMPANY, LIMITED, have determined to dispose of the Phœnix Foundry, Barry, and their shop on the East Bute Dock, as going concerns. The company's business will, in the future, be concentrated at Newport.

MESSRS. WALTERS & COMPANY, engineering agents and power and lighting engineers, of Ocean Chambers, Birmingham, now hold the sole agency in Birmingham and the Midland Counties for Greenwood & Batley, Limited, of Leeds.

The Effect of Superheated Steam on Cast Iron and Steel.

The following are abstracts of three Papers:—"Cast-Iron Fittings for Superheated Steam," by Prof. Ira N. Hollis; "The Effect of Superheated Steam on the Strength of Cast Iron, Gun Iron and Steel," by Prof. Edward F. Miller; and "Cast-Iron Valves and Fittings for Superheated Steam," by Arthur S. Mann—presented before the American Society of Mechanical Engineers, and published in their "Proceedings."

Cast-Iron Fittings for Superheated Steam.

The failure of a number of large cast-iron fittings in use with superheated steam has rightly created a widespread suspicion of this material when exposed to high temperature. Yet on this subject there is very little information of a character to justify the wholesale substitution of steel castings for the ordinary heavy cast-iron fittings. The doubt as to the reliability of cast iron has seemed to spring up with its use in long pipe lines to steam turbines where the temperature has ranged from 550 degrees to 600 degrees. This would lead one to ask if the difficulty has not been in the design of the piping systems rather than in the character of the material. Has not the cast iron taken the brunt of a new service, and has it not suffered in the estimation of the engineering public because the conditions of that service were not fully understood?

This brief paper is only intended as a record of some tests that may throw light on the subject. These tests were made for the Edison Illuminating Company, of Boston, for the purpose of determining the bursting strength under hydraulic pressure of some large fittings which were replaced with steel castings. It may be well to enquire what is actually known about cast iron subjected to high temperature; that is, known without the possibility of controversy: —(*a*) Fittings have developed cracks and small changes of shape after a few months of actual service; (*b*) fittings exposed separately to superheated steam at a temperature exceeding 500 degrees F. have shown a permanent increase of some dimensions; (*c*) the tensile tests of pieces cut from fittings that had failed in service indicate in some cases the possibility of permanent loss of strength.

The remainder of the evidence in the case may be classed as good guesswork based upon some preconceived theory as to the behaviour of the constituent parts of cast iron in a rising temperature.

One of the curious and interesting qualities of cast iron is its permanent increase of dimensions under high temperature. This is paralleled by the permanent set of cast-iron test pieces when subject to very moderate tensile stresses. In both cases the cast iron apparently continues to grow at a decreasing rate, at least in some dimensions, when the high temperature or tensile stress is repeated. How long this growth would continue is not known. Its probable limit is the flow of the material under the ultimate breaking stress. Cast iron may not be peculiar in this respect, and all materials may change permanently their dimensions under moderate stress, the change growing with each imposition of the same stress. There is no doubt of this where the yield point has been exceeded. It may also be that all materials change permanently under repeated application of high temperature.

The cause of the persistent expansion under high temperature is still very obscure, but two possible agencies have been mentioned in a number of discussions:—(*a*) A chemical, or physical, change in the relation of the iron to the various foreign substances which fix it as cast iron; (*b*) a molecular change due to the fact that cast iron has no well defined elastic limit or modulus of elasticity.

Both causes may be in operation at the same time, but the theory of chemical change has far less standing than that relating to the stresses produced by unequal expansion. While there is a temperature at which carbon changes its relation to the iron, superheated steam is probably well below that point except under very unusual conditions. That cast iron loses strength when exposed to superheated steam at 600 degrees is not conclusively proved. The most that can be said is that test specimens taken out of cast-iron fittings after one year's or more exposure to a temperature of 550 degrees to 600 degrees have shown a surprising irregularity of strength in the same casting. But there is nothing to prove that new cast-iron fittings have not a great lack of homogeneity.

The Paper then goes on to describe the essential features of the Edison station as follows:—The new part of the station is arranged in a series of complete units each consisting of one vertical Curtis turbine and eight boilers set in pairs. The main steam line extends along the rear ends of the boilers just beneath the brickwork, four 8-in. vertical steam mains connecting each pair of boilers with the main line. Three of the vertical mains discharge through gate valves into T's, and the fourth, at the end of the line, through a gate valve into a bend.

The first turbine units were provided throughout with cast-iron fittings, which were ultimately replaced with steel fittings. No expansion or slip joints are used. The main steam line (something over 103 ft. long) is anchored at the turbine end, and is allowed to expand freely in a longitudinal or horizontal direction, carrying the lower ends of the vertical mains with it. The steam pressure is 175 lbs.; the superheating generally amounts to 150 degrees F., although it is not constant. The actual temperature of the steam varies from 500 degrees to 580 degrees, so that the main line is changing in length from time to time, thus moving the lower ends of the vertical mains back and forth. A series of variable stresses are consequently introduced into all parts of the pipe system, probably affecting most seriously the T's. It is this aspect of the case, namely, the effect of varying stresses upon cast iron at high temperature, that must be studied before a sound verdict can be reached.

The Paper then goes on to describe the testing of a series of pieces taken from the different T's.

It was fully recognised in the first of the tests that, while the material might not have suffered in service, nevertheless parts of the casting might have been weakened by the expansion stresses. For the purpose of testing this, two T's were removed from the line and broken by internal hydraulic pressure, thus affording a definite idea of the strength of the castings as a whole. A third casting, an L, not previously in use, was added for comparison, but the two T's which had been exposed to superheated steam of 578 degrees F. and less for fifteen months, or longer, when removed gave no indications of weakness. A careful examination disclosed no appreciable distortion, except in the faces of the flanges, which were no longer plane surfaces.

As to the stress which existed in the T during its

service, that due to the steam pressure was small when compared with the actual bursting pressure, but that due to expansion may have been serious in its effect. The first T in the main steam line was located at 4 ft. 8⅝ in. from the anchorage, the second 37 ft. 8⅝ in., the third 70 ft. 8⅝ in., and there was no expansion joint to ease off the pressure on the vertical mains. Taking the third T for purposes of illustration, certain suppositions can safely be made:—(*a*) The lower flange of the vertical pipe moves in a horizontal plane as the main pipe expands, and, therefore, the lowest point of the axis of the pipe moves parallel to itself. (*b*) The upper end of the vertical pipe is practically fixed. The expansion of the main steam pipe thus puts an S bend in the vertical pipes, and introduces large bending movements into both ends of it and into the T. The actual length of the pipe between its lowest flange and the upper end is 26 ft., but the length between the upper surface of the T and the upper end of the pipe is about 28 ft.

The linear expansion of the main steam line is about 3 in. when heated to 578 degrees F. The effect of this is supposed to be halved by cutting the pipe short and springing the flanges into place when making the joints. There is thus an initial deflection in the vertical pipe. This is overcome as the pipe is heated and carried as much farther on the other side.

After calculating the stress set up in the pipe by the deflection, the author proceeds:—This calculation is made under the supposition that the expansion of the pipe was lessend by an initial pull, and that all the joints came exactly fair before setting up the bolts. It is easy to imagine how serious the stresses might have become under actual conditions of inaccurate fitting. The one element of splitting the expansion is very uncertain. The stress might easily have been doubled, resulting in pulling the T quite out of shape, and in setting up internal strains certain to weaken the material in places.

Under such conditions, it would generally be wise to replace cast-iron Ts with cast steel, which would yield more readily to expansion, and which would be safer at much higher tensile stresses. The reason for the substitution ought not to be lost sight of in such a case, if cast iron is to be judged fairly. It is made because it is cheaper, on the whole, to replace the cast iron with steel rather than to put in expansion or slip joints. Perhaps the steel casting is also much easier to take care of than any form of expansion joint. The unreliability of cast iron in such a service has nothing to do with the case; it is merely that the design usually adopted for steam piping does not quite fit cast iron.

The Effect of Superheated Steam on the Strength of Cast Iron, Gun Iron, and Steel.

This Paper describes some experiments made to determine the effect of superheated steam on cast iron, gun iron, and steel. From each piece to be tested two tension specimens were made, one to be subjected to the action of superheated steam, and one to be used in obtaining the original strength of the piece. The specimens to be subjected to superheat were placed on a wire grating suspended at the centre of a 12-in. iron pipe about 3 ft. long, supported horizontally on brackets. The ends were closed by blank flanges. Steam was supplied by a small pipe, a flow at low velocity being maintained at all times. The under side of the pipe was heated by Bunsen gas burners. Thermometers, in wells reaching down to the grating on which the specimens were placed, gave the temperature of the steam, the pressure being read from a steam gauge on the supply pipe.

For the tests the average gauge pressure in the superheating pipe was 93 lbs., and the average temperature 660 degrees F. The gas flame was extinguished at 5 p.m., and lighted again at 7 a.m. The temperature reached 660 degrees F. by 11 a.m., and by 5 p.m. would be as high as 700 or 720 degrees F. Steam was kept in the superheater during the night. The total time these specimens were exposed to superheated steam was 260 hours, and the exposure to saturated steam was 460 hours. A chemical analysis of the iron tested was as follows:—

	Total C.	Gc.	Mn.	Si.	S.	P.
Cast Iron, Gibby Foundry	3.51	3.02	0.37	1.88	0.05	—
Gun Iron, Hunt ... Spiller	3.25	2.60	0.24	0.54	0.09	0.41
Cast Iron, Broadway Foundry ...	3.34	2.84	0.38	2.26	0.09	—

For further tests which were made the average gauge pressure was 82 lbs., and the average amount of superheat about 390 degrees F. These specimens were subjected to superheated steam for 520 hours, and to saturated steam for 920 hours. A chemical analysis of three of the semi-steel specimens was as follows:—

Total C.	Gc.	Mn.	Si.	S.	P
—	2.64	—	—	0.11	—
3.48	2.39	0.35	1.91	0.11	0.24
3.22	2.83	0.44	2.62	0.49	0.61

This semi-steel was made by adding 200 lbs. of steel to 1,500 lbs. of cast iron. The analysis of the gun iron showed—total carbon, 3.37 per cent.; graphite, 2.44 per cent.; manganese, 0.34 per cent.; sulphur, 0.11 per cent.; and silicon, 1.65 per cent.

The composition of two of the rolled-steel pieces, No. 26 and No. 27, was as follows:—

	Total C.	Mn.	Si.	S.	P.
No. 26	—	0.73	0.026	0.026	0.85
No. 27	—	0.90	0.031	0.037	0.116

A comparison of the ultimate strength per square inch of the original specimen, and the strength per square inch of the specimen which had been subjected to the action of superheated steam, indicates that the cast iron from the Broadway Foundry lost 9.5 per cent.; that of the Gibby Foundry 2.4 per cent. The cast iron in the second series of tests apparently shows a gain in strength of 1.8 per cent. The gun iron shows a loss of strength of about 3.5 per cent. in the first tests, and about 2.1 per cent. in the second tests.

The tests on semi-steel show an average reduction of strength, due to exposure to the steam, of about 0.4 per cent., four out of six pieces showing quite a reduction. Four grades of steel were tested; two pieces from a bar of 65,000- to 70,000-lbs. tensile strength, two from a bar of 75,000- to 80,000-lbs. tensile strength, two each from three bars of about 90,000-lbs. tensile strength, and two from a bar of over 100,000-lbs tensile strength. The 65,000- to 70,000-lbs. steel showed a loss of 1.8 per cent. due to exposure to the steam, the 75,000- to 80,000-lbs. steel a loss of 1.9 per cent., the 90,000-lbs. steel a loss of 1.5 per cent., and the 100,000-lbs. a loss of 24 per cent.

While one is not justified in drawing many conclusions from the results of as few tests as are quoted

here, still it is evident that the metals tested have suffered a loss in strength due to their exposure to the steam.

Cast-Iron Valves and Fittings for Superheated Steam.

No doubt cast-iron fittings and valves can support a steady pressure of 200 lbs. without bursting, but there have been many failures when carrying superheated steam of lower pressure. The fittings which are listed in many manufacturers' catalogues as suitable for 200-lbs. pressure, and which have to meet a close price competition, are not too well suited for permanent work of even 150 lbs. pressure, and many engineers prefer to design their own parts rather than to trust the usual run of commercial extra-heavy fittings. Probably on account of the advertised ability to support a high steady pressure these extra-heavy fittings and valves have been used in a number of instances for superheated work. After a short time, six months or even less perhaps, cracks make their appearance; valves leak, seats become loose, castings grow in length, and surface cracks become so large in size and in number that the casting is removed from the line.

A few repetitions of this experience seem to justify the conclusion that cast iron is not fit material for high-temperature steam. The natural substitute is steel, which is used with fair, even complete, success in many cases.

It is known that cast iron will grow with repeated heatings and coolings, and a rough experiment was tried by the writer with two samples, one of an ordinary cast iron, and a second of a high-grade cast iron, which has proved itself capable of carrying superheated steam and of which a detailed analysis is given in the course of this Paper. The two samples were each 6 in. long and 1 in. in diameter. They were placed in a banked fire over night, reaching a dull red heat, and were allowed to cool in the air. A slight growth, as measured by micrometer, was found in each piece. This treatment was followed for two or three nights and the growths were measured. There was an increase in the length of each of the samples, the high-grade iron having increased in length slightly more than did the ordinary iron. The experiment, so far as it went, tended to show that the growth of cast iron does not necessarily unfit it for the usual degree of superheat in power-house work.

Many grades of brass will crumble when heated in a forge to a barely visible red, and are quite unfitted to support any stress at such a temperature. But this characteristic in no way unfits very ordinary cast brass for saturated steam work, and one should not hesitate to use a valve of cast brass up to 3 in. in diameter for 150 lbs. saturated steam pressure. Three inches is not usually exceeded, because valves with large brass bodies are expensive.

Cases of failure have been cited to prove that something better than ordinary cast iron was needed for steam of 180 lbs. pressure and 250 degrees superheat. These failures came from two causes. In the first place the iron itself was not of sufficiently good quality; and, secondly, the parts were not thick enough. The static stress probably did not exceed 1,000 lbs. in the body; but static stress is not the important load which fittings have to support.

Stresses from expansion and contraction within and without the casting and stress from pulling up joints no doubt greatly exceed the static load even in pipe very carefully erected. The troubles are aggravated by the action of the steam itself, but it is yet to be proved that the steam or its high temperature will of itself start cracks in a properly designed fitting.

The ordinary commercial extra-heavy flanged T, 8 in. inside diameter, has a body $\frac{7}{8}$ in. and flanges $1\frac{5}{8}$ in. thick. It is made of common iron, having a tensile strength of about 18,000 lbs. Such a fitting will fail with superheated steam at 175 lbs. pressure and 200 degrees superheat. Within a year the inner surfaces will have a network of cracks, some of which will increase in depth till they extend through the body. The flanges will crack outward from the bolt holes and the fitting will become not only leaky but dangerous as well. The writer has observed just such castings, and similar effects have been experienced by a great many steam users, but the fittings are inherently weak to begin with, so that the failures do not prove that a heavier fitting of better iron is unsuited for superheated steam work.

Within the experience of the writer steel fittings have failed with superheated steam. Out of twenty-five steel gate valves, 6, 8, and 10 in. in diameter, not more than four were fairly tight after one year's service, the bodies themselves yielding enough to leak badly. Some defects in the castings developed, allowing steam to pass straight through the walls, when they left the foundry. Some of these defects were such that the fittings and valves could not be repaired. In some cases seats were scraped in once or twice, and holes were plugged up or patched. Yet all these castings were heavy, materially thicker than the commercially extra-heavy cast-iron product, and had passed a rigid inspection.

No doubt a thoroughly sound steel casting is able to withstand highly superheated steam. So far as it has been possible to observe, superheated steam does not of itself initiate defects, and it is not supposed that the sound metal undergoes a change, either chemically or structurally. But if there is an initial defect, superheated steam is much more active in bringing out the objectionable features of that defect. It may well be that the material within the body, and not a part of the actual metal, suffers through change of some sort. This material does not add to the strength of a casting, but it may serve to stop up holes if allowed to lie undisturbed.

It would appear that some material better than the ordinary steel casting is desirable for high-temperature work. Such a material is found in gun iron. Gun iron is nothing more than a high-grade cast iron, which any first-class iron foundry can produce. In the days of the smooth-bore cannon a few foundries discovered that it was possible to produce an iron having a tensile strength of 30,000 lbs., or more. The Government specified it for its guns, and it was called gun iron. Probably a tensile strength of 30,000 lbs. is not needed in steam fittings, but iron of that quality is well adapted for 180 lbs. steam with 300 degrees superheat.

It appears that certain elements in the iron are liable to cause trouble when present in excess, and perhaps the worst of these is silicon, though it is at present going too far to say that every high-silicon iron will fail, and that every low-silicon iron will prove successful. In any event iron of low silicon, low phosphorus, and low carbon—in other words, gun iron—has proved successful.

A FIRE broke out on January 14 at the Cornwall Works, Smethwick, of Tangyes, Limted, and before it was brought under control serious damake had been done to one of the most important sections of the premises. The flames were first discovered in the cellar of the pump department and quickly spread. After practically gutting this department, the high wind carried the flames to an adjoining department, but this building was saved before the damage became serious.

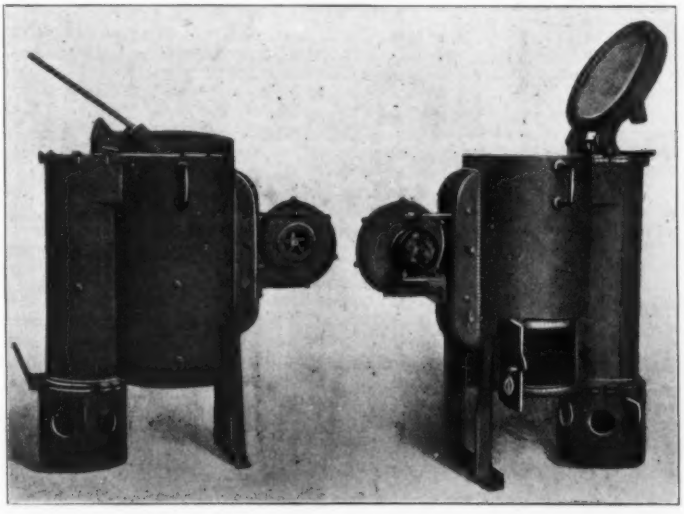
Foundry Plant and Equipment.

A Portable Mould Drier.

Herewith illustrated is a portable mould drier designed by the Hanna Engineering Works, Chicago, Ill., for reducing the cost of producing moulds for foundry work. The drier consists simply of a furnace chamber and a distributing pipe through which the heated air is driven. The body of the drier is made of grey iron castings provided with a lining of split firebrick, all joints being securely closed with clay. A rocking grate, which is also removable, is fitted in the bottom of the combustion chamber, which is about on a level with the top of the ash pit door. Coke is charged from the top, which is covered by a hinged lid raised and lowered by a projecting lever. Air blast is introduced either above or below the fire, as may be desired, its course being controlled by two dampers.

In starting, blast to the fire is admitted through the lower damper, and when thoroughly burning the air current is shifted to the combustion chamber, whence the heat is carried into the distributer and through connecting pipes to all the interior parts of the mould. These connecting pipes are inserted in holes provided in the bottom of the distributer and sealed with clay. Similar air-tight connections are made by means of ordinary fittings at the mould openings.

Sufficient air for the operation of the drier is furnished by a 12-in. motor-driven fan, either direct or alternating current, of 1-5 h.p. capacity, the current for which can be supplied from an ordinary lamp socket on a lighting circuit. The fan and motor are bolted to the furnace casting, so that the entire equipment is self-contained, and by means of side lugs or handles near the top the drier can be conveniently lifted with a crane for transfer about the shop. The weight of the drier is 1,850 lbs.



Two Views of Portable Mould Drier.

The time required for dyring a mould depends upon its size and the limit of time within which it is required for use; on large moulds one or more driers may be used, thus hastening the process. One drier of this kind, it is claimed, will dry a mould for a 9,000-lb. casting in 10 hours, with a consumption of 400 lbs. of coke. In one instance a mould 27 ft. long, 9 ft. deep and 11 ft. wide for a 92-ton casting was dried with five driers running continuously for 60 hours, and burning 4,500 lbs. of coke. The fuel cost is economised by the use of refuse coke from bins and cores.

An Improved Water Cinder Mill.

An example of the economies effected by the saving of material that is ordinarily wasted, is seen in the application of apparatus such as that shown in Fig. 1, which illustrates a water cinder mill designed and made by the Central Iron Works, Quincy, Ill., for saving iron and coke from cupola cinders and gangway cleanings. It is guaranteed to recover 95 per cent. of the iron and about 80 per cent. of the coke from cupola cinders and gangway cleanings.

The installation includes a tank of brick and concrete divided into three compartments, the first of which is located directly under the mill and contains

the water supply for the pump; the second is used as a settling basin and the third for refuse matter. Cinders are first crushed in the mill and are then flooded with water raised from the tank by a centrifugal pump which separates the iron from cinder and coke, carrying the latter out of the mill barrel through a hollow trunnion into a connecting cylinder screen.

countersunk rivets. The rivets being driven flush with the shell on the inside, a smooth, even surface is provided and the wear on the rivet heads is only equal to that of the shell.

Water for the washing process is supplied by a centrifugal pump placed in the tank below the mill, as shown. To protect it from the cutting effect of

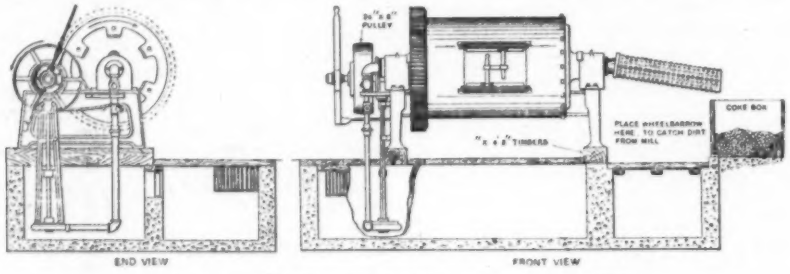


FIG. 1.—WATER CINDER MILL; SECTIONAL VIEWS.

Revolving with the mill, the screen sifts out the dirt and cinders and discharges the coke into a convenient receptacle.

The mill cylinder is formed of a rolled steel plate 1 in. thick and contains a separating head at each end. It is belt-driven through a shaft and spur gear which engages with a large gear encircling the circumference of one end of the shell. Ball and socket ring oiling bearings are provided for the trunnion and pinion shafts. The shell is joined on its longitudinal seam with a butt strap joint with deeply

sand and grit, the shaft bearing is lined with hard maple plugs bored to fit the shaft. To allow room for impurities that may find lodgment in the bearings to work out, a small space is left between each plug so that trouble from this source is minimised. The pump may also be used for draining the tanks, and to use it in this manner a hose is attached to the tee on the inlet pipe when, after closing the stop cock above it, water is diverted through the hose. The operation of the mill is stopped and started through a friction clutch.

The Rapid Moulding Machine.

The machine depicted in the accompanying illustrations has been designed to meet the demand for a reliable and serviceable article at a modera'e cost. It is intended for hand ramming, and does not require compressed air, hydraulic, or any other motive power. It consists of a planed table, supported on

stripping plates. Moulding boxes of several sizes can be used on each machine, an extra plate or set of stripping plates being recommended for each size; these are easily fixed and quickly changed.

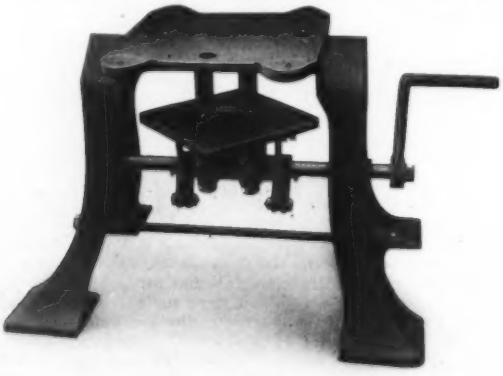


FIG. 2.—THE RAPID MOULDING MACHINE.

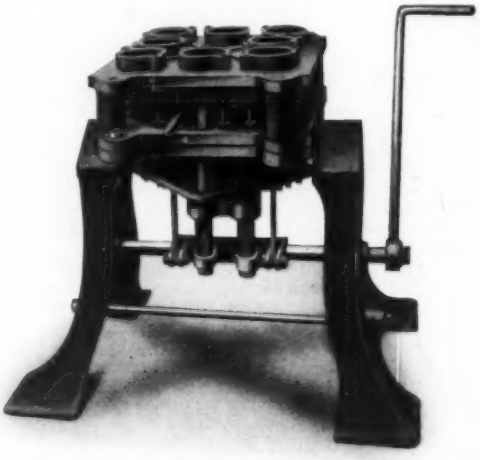


FIG. 1.—THE RAPID MOULDING MACHINE.

legs, braced with a collared tie bolt, thus giving firmness and rigidity, and is usually made to suit some standard size moulding box.

The rising plate underneath the table is operated by a double crank shaft, with handle, and has a 5-in. travel, either for lifting the moulding boxes off the patterns, or for drawing the patterns through the

The daily output for two labourers is about 100 pairs of boxes in eight hours; they prepare the sand, pour the metal, empty the boxes, and re-mix the sand ready for use.

The makers of the machine are Messrs. Jones & Attwood, Stourbridge, to whom we are indebted for these particulars.

Inventions.

Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

1909.

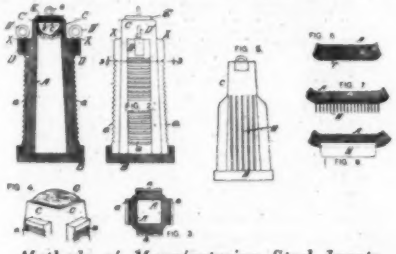
29,076. Manufacture of crucible steel. A. Reynolds.
29,482.*Manufacture of steel. A. Reynolds.
29,537. Gas valve for economising gas for melting or mill furnaces. W. Lewis, 2, Florence Place, Griffiths Town, Newport, Mon.
29,671.*Electric furnaces. O. Vogel.
29,916. Method of alloying lead and aluminium. R. S. Portheim, 33, Barton Arcade, Manchester.
30,073. Annealing furnaces. R. F. Hislop and G. R. Hislop, jun., 62, St. Vincent Street, Glasgow.
30,428.*Cast metals. R. C. Totten.

1910.

20. Apparatus for use in casting metals. E. A. Jeffreys, B. Stevens, and J. Deakin, 58, St. Vincent Street, Glasgow.
232, Alloys, P. R. Parsons and O. Silberrad.
264. Automatic weighing apparatus. W. E. Hipkins and J. J. Burrows, Soho Foundry, Birmingham.
672.*Electrical induction smelting furnaces. O. Mulacek and F. Hatlanek.
673 & 674.*Electrical induction furnaces. O. Mulacek and F. Hatlanek.
684.*Phosphorous metal composed of manganese and antimony. L. Goldberg.
707. Zinc-distilling furnace. H. Martin and J. R. Down, Adelaide Street, Swansea.
994. Manufacture of steel. A. Reynolds.
1,115.*Gas-fired furnaces for heating bars, rod iron, etc. P. Schmidt, 78, Fleet Street, London.

Abstracts of British Patent Specifications recently accepted.

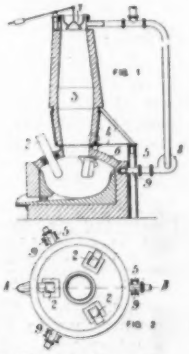
11,033 (1909). *Methods of Manufacturing Steel Ingots and Moulds therefor.* E. Gathmann, 54, Lehigh Avenue, Bethlehem, Pennsylvania, U.S.A.—The invention relates primarily to the casting of steel ingots or alloy ingots which contract in their freezing or solidification from the hot liquid casting, and which are subsequently pressed, rolled, or hammered into various commercial structural shapes and forgings. The primary



Methods of Manufacturing Steel Ingots and Moulds therefor.

object of the invention is to manufacture steel ingots in such manner that the pipe or cavity which forms in the upper middle portion of the ingot is practically eliminated. Another object is to so mould the ingots that ingotism or the formation of large crystals in the structure of the ingot is greatly reduced. Figure 1 shows a vertical central section through an ingot mould which may be employed in carrying out the invention; Figure 2 shows a side elevation of the mould shown in Figure 1, the stool or base being in section; Figure 3 shows a horizontal section on the line 3—3 of Figure 2 looking in the direction of the arrows; Figure 4 is a perspective view showing a modified way of closing the top of the mould; Figure 5 shows a side elevation of a modified form of mould; Figures 6, 7 and 8 show other ways of effecting the absorption and radiation of heat in the lower portion of the mould. An essential characteristic of the moulds is that their construction is such that all the molten mass below a relatively small part at the upper end of the mould, is cooled by radiation more rapidly than the feed molten metal to the pipe or cavity formed in the lower portion of the mass while the latter is freezing, or contracting, and until the solidification of the ingot is completed. This may be accomplished in various ways. In the mould shown in Figures 1, 2, and 3, the lower part below the line X—X is relatively thick, while the upper part of the mould above the line X—X is relatively thin. This ensures a quicker absorption of heat from the lower part of the molten mass, and the lower part of the mould below the line X—X is provided with roughened or serrated surfaces, as indicated at *a*. As shown, these surfaces are provided by employing horizontally-arranged ribs and intervening grooves, as this construction is well adapted to favour heat radiation.

17,342 (1909). *Electric Furnaces.* Aktiebolaget Elektrometall, Bergatan, 43, Stockholm, Sweden.—The lower portion of the shaft communicating with the smelting chamber is constructed in such a form that it expands upwards. Thus, at the bottom, a contraction is formed, through which the material must pass before coming into the wider smelting chamber arranged below. Consequently, a part of the pressure of the material in the shaft is taken up by the conical walls of the shaft, so that the pressure upon the material in the smelting chamber is reduced, and the existence of free spaces is made sure. Figure 1 represents a vertical section of the furnace drawn on the line A, B, in Figure 2, which latter is a plan of the smelting chamber. 1 is the smelting chamber, corresponding to the so-called hearth in an ordinary blast furnace, where the electrodes 2 are put in contact with the charge.



Electric Furnaces.

3 is a shaft which, by means of an iron structure 4, rests on pillars 5 in order that it may not press on the cupola 6, covering the smelting chamber. The lowest part of the shaft has, as can be seen from the drawing, a smaller interior diameter than either the smelting chamber or the higher part of the pipe or shaft. The fact that the furnace, above the smelting chamber, has a contracted part from which the smelting chamber expands downwards and the shaft expands upwards, and that the electrodes are arranged in such a way that they come into contact with the charge below this contracted part, constitutes the characteristic feature of the invention. The cupola 6 should be formed or curved in such a way that, between the walls of the cupola and the charge which is sinking down through the shaft, there shall always be one or several free spaces. The electrodes 2 should be so placed that they enter into the charge at places where such free spaces exist. By means of this arrangement no considerable degree of heat will be developed in the immediate neighbourhood of the brickwork, whereby the latter will be afforded the greatest protection possible from the heat.

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F.T.J. Bookshelf.

Publications Received.

THE "PRACTICAL ENGINEER" POCKET BOOK AND DIARY FOR 1910. London: The Technical Publishing Company, 55 and 56, Chancery Lane, W.C.

The utility of this pocket book, which has in previous years found considerable favour amongst the engineering public, remains unimpaired in the new edition. Some additional items have been added, including notes on fuel testing, condensers, friction of air and water in pipes, alloys, table of properties of metals, pyrometry, suction gas producers, etc., all of which help to maintain the value of the compilation.

THE "PRACTICAL ENGINEER" ELECTRICAL POCKET BOOK AND DIARY FOR 1910. London: The Technical Publishing Company, Limited.

The new edition of this helpful pocket book has been overhauled in order to bring it up to date, and the whole of the articles on magnetos, dynamo design, etc., have been revised by Mr. C. C. Hawkins, M.A. (Oxon). Among the new items are storage batteries, the design of motor starting resistances, water resistances for testing purposes, the transformation of currents for power purposes, types of underground boxes, and a number of others.

THE SCIENCE YEAR BOOK AND DIARY FOR 1910: London:—King, Sell and Olding, Limited, 27, Chancery Lane, W.C.

This is the sixth year of issue of this book, which includes astronomical, physical, and chemical tables, and a summary of progress in science. It embodies a lot of interesting and valuable information on scientific subjects. Several features which do not appear to have met with special demand have been omitted, but many additions have been made, such as a map of coming solar eclipses, details of airships and aeroplanes, prices of metals, etc. Very handy, too, is the directory of periodicals, societies, prizes, and awards. In the diary section of the book one page is allotted to each day, and other pages are ruled for a monthly cash account.

HODGES & COMPANY, 14, Devonshire Square, Bishopsgate, E.C. An illustrated circular relating to their turbine blowers and steam-turbine-driven fans for foundry use has been issued by this firm. An improvement, recently introduced into these appliances by Mr. R. J. Hodges, now enables them to be constructed for air pressures up to 20 lbs. per square inch. One of these latest types of turbine blowers, with direct-coupled motor, has recently been supplied by the firm to Messrs. Bolckow, Vaughan & Company, Limited, for their new foundry at Middlesbrough, and is stated to exhibit remarkable economy, absorbing only 2.4 h.p. of electrical current per ton of metal melted.

Reply.

Books on Cupola Practice.

A reader enquires for particulars of a book on cupola practice, but we cannot at the moment trace a work devoted entirely to that subject. There was, certainly, a very comprehensive work, by Edward Kirk, on "Foundry Cupolas," but we learn from the British representatives of the publishers, that this is now out of print, and cannot be obtained. In a number of foundry text-books, however, will be found sections dealing with cupola practice; amongst these may be mentioned "The Moulder's Text-Book," by Thomas West (this being Part II. of "American Foundry Practice"). In this book are given, in addition to a general section dealing with cupolas, forty-six reports of cupola workings collected by the author, and relating to American cupola practice. Other authors have also presented a good deal of useful information on the subject in their text-books, and it is scarcely safe to recommend any particular one as being the best.

THE EDITOR, F.T.J.

Queries.

Mixture for Brake-Blocks.

Will any reader kindly give a good mixture of metal for brake-blocks, chilled and ordinary?

"H. L. F. C."

Alloying Nickel and Cast Iron.

Will any of the readers of this Journal give me information as to the best methods of alloying or mixing nickel with cast iron. I desire to cast a number of small parts which are subject to steam containing acid matter, and think that a mixture of these metals will give a good wearing material.

"P. J. S."

Personal.

THE late Mr. W. H. Tylor, of J. Tylor & Sons, Limited, iron and brass founders, left estate valued at £63,848 gross.

THE late Mr. R. F. Martineau, J.P., of Edgbaston, of Martineau, Beames & Madeley, Limited, brass founders, left estate valued at £8,486.

PERSONAL estate valued at £768,420 has been left by the late Mr. Alexander Fleming, of Wm. Baird & Company, Limited, ironmasters, Glasgow, who died in October last.

PROFESSOR H. PAYNE, Professor of Engineering at the South African College, Cape Town, has been appointed to the Chair of Engineering at the Melbourne University, Victoria.

THE gross value of the estate left by the late Mr. William Statham, of The Redings, Totteridge, Herts., a director of Andrew Handyside & Company, Limited, is £50,983, with net personalty £44,142.

PROF. WM. GOWLAND, past president of the Institution of Mining and Metallurgy, has been appointed Emeritus Professor of Metallurgy at the Royal School of Mines, by the Governing Body of the Imperial College of Science and Technology.

MR. H. PILKINGTON, M.I.C.E., M.I.Mech.E. (past president of the British Foundrymen's Association) of the Sheepbridge Coal and Iron Company, Chesterfield, has been appointed as the representative of that Association on the Committee of the International Association for Testing Materials.

MR. JAMES DUNN has resigned his position as a director of Vickers, Sons & Maxim, Limited, but will act in future as consulting naval architect for the company. Mr. James M'Kechner has now been elected a director to fill the vacancy on the board caused by Mr. Dunn's resignation, and will be resident at Barrow-in-Furness.

THE death is reported of Dr. Charles B. Dudley, chief chemist for the Pennsylvania Railroad Company, U.S.A., aged 68 years. He was one of the most prominent scientists in the United States, and won international fame as a testing engineer. He was a graduate of Yale College, a doctor of philosophy, president of the American Chemical Society, member of the British Iron and Steel Institute, president of the American Society for Testing Materials, and was recently elected president of the International Society for Testing Materials at the meeting of the society held in Copenhagen.

Trade Talk.

BABCOCK & WILCOX, LIMITED are removing their Manchester office from 14, Deansgate to 30, Cross Street.

JAMES SLATER & COMPANY, LIMITED, engineers, have removed to 50 and 51, Wells Street, Oxford Street, London, W.

MR. A. P. HASLAM has established himself in business at Suffolk House, Laurence Pountney Hill, London, E.C., as an engineers' agent.

WE understand that a well-known Rotherham firm have acquired land at Kilnhurst on which to erect works for the building of railway wagons.

MESSRS. A. ASH and H. M. PARTRIDGE, ironfounders, Willenhall, Staffs, trading under the style of Arthur Ash & Company, have dissolved partnership.

THE UNDERFEED STOKER COMPANY, LIMITED, have appointed Messrs. D. T. Keymer & Company, 5, Mangoe Lane, Calcutta, as their Indian agents.

MESSRS. W. DARBY and I. DARBY, metal workers, Weston Street, London, W.C., trading under the style of Darby & Sons, have dissolved partnership.

WALLACH BROTHERS, LIMITED, Royal London House, Finsbury Square, London, E.C., have been appointed sole agents for the Turner Oil Filter Company.

MESSRS. WATSON & WHYTE, 19, Waterloo Street, Glasgow, have been appointed agents for Glasgow and district for Feld Brothers & Company, Limited.

MESSRS. SIMKINS & HADLEY, Baltic Works, Willenhall, will in future manufacture the locks of Stevens Patent Lock Co., 38, Crutched Friars, London, E.C.

MR. V. O. CUTTS, lately connected with Mr. T. Scott Anderson, consulting and contracting engineer, Sheffield, has established himself in business as an engineer.

A FIRE occurred in a foundry at the works of John Brown & Company, Limited, Sheffield, recently. The damage was fortunately confined to the roof and woodwork.

AN outbreak of fire occurred at the premises of Saunders, Davies & Company, Limited, brassfounders, 90, Dartmouth Street, Birmingham, recently, but the damage was not heavy.

A 250-KILO electrical furnace of the Grondal Kjellin type is being installed at the Brightside Works, Sheffield, of Wm. Jessop & Sons, Limited, by Wellman, Seaver & Head, Limited.

A DISSOLUTION of partnership is notified in connection with Messrs. H. D. B. How, and W. W. Partington, engineers, Taffs Well, Glam., who traded under the style of How, Partington, & Company.

MESSRS. RD. WHITE & SONS, of Widnes, have recently secured orders for switches and crossings from the G.I.P. Railway, and also from the Agent-General of the Transvaal for the Central South African Railways.

MESSRS. H. HASTINGS and T. C. ROBERTS, electrical and general engineers, etc., Barcelona, Spain, and Queen Victoria Street, London, E.C., trading under the style of Hastings, Roberts & Company, have dissolved partnership.

THE business of the late William Baird, engineer and bridge builder, Temple Iron Works, Temple, Glasgow, carried on under the style of William Baird and Son, has been acquired by Mr. W. M. Baird and Mr. W. C. Warrand.

THE WILLINGSWORTH IRON COMPANY, LIMITED, have appointed J. C. Abbott & Company, Limited, Prince's Chambers, Corporation Street, Birmingham, their sole agents for the sale of Willingsworth basic, forge, and foundry pig-iron.

HICKMAN, BATCHELOR & COMPANY, LIMITED, Broad Street House, London, E.C., have been appointed by Messrs. W. N. Brunton & Son, of Musselburgh, Scotland, as their sole representatives so far as the export trade in London is concerned.

MESSRS. TRIER BROTHERS, engineers and manufacturers, 1, Great George Street, Westminster, S.W., and the Cumberland Works, New Church Road, Camberwell, London, S.E., have removed their offices to Caxton House, Westminster, London, S.W.

HICKMAN, BATCHELOR & COMPANY, LIMITED, Broad Street House, London, E.C., have been appointed by Wright, Bindley & Gell, Limited, of Birmingham and Sheffield, as their sole agents for London, as concerns the export trade to Japan and China.

MESSRS. H. MARCOTTY, Broad Street House, New Broad Street, E.C., have taken up the sole agency of the United Kingdom for home and export of Messrs. Malmedie and Co., of Dusseldorf, manufacturers of all kinds of machinery for making wire nails, etc.

VICKERS, SONS & MAXIM, LIMITED, of Barrow have placed an order with Masons Gas Power Company, Limited, Manchester, for shipyard furnace plant, consisting of gas producers, ship frame furnaces, steel chimney, the necessary flues, etc.

THE partnership heretofore subsisting between Mr. H. E. Smith and Mr. J. W. H. Hawes, formerly carrying on business as engineers at 52, Frederick Street, Edinburgh, and 233, St. Vincent Street, Glasgow, under the style of the Tayler Smith Company, has been dissolved.

MESSRS. P. H. BONVILLIAN & E. RONCERAY, Paris, manufacturers of foundry moulding machines, American patent rights for which have been controlled for the past two years by the E. H. Mumford Company, Philadelphia, have taken over the patents and equipment from that Company.

RICHARD NEVILL & COMPANY, LIMITED, Wern Iron Works, Llanelly, South Wales, are making a large rolling mill engine flywheel for the new plate mills that are being installed at the Orb Iron Works, Newport, Monmouthshire, of John Lysaght, Limited. The wheel when completed will weigh 120 tons, and have a diameter of 32 ft.

THE trustee of the sequestrated estate of Ralston, Goodwin & Company, Craighall Iron Works, Glasgow, intimates that an account of his intromissions with the funds of the estate brought down to December, 15, 1909, has been audited by the commissioners, who have postponed the declaration of a dividend till the recurrence of another statutory period.

THE price of space at the Engineering and Machinery Exhibition is the same to all, viz., 4s. or 3s., regulated by position. Exhibitors desiring electricity for power will be charged the net rate fixed by the Manchester Corporation, which will not exceed 1½d. per unit. The voltage for 3 h.p. and over is 400. Electricity for lighting purposes is 200 volts, and will be charged at a net rate.

MR. G. BRAULIK, engineers' agent, of 217, Upper Thames Street, London, E.C., and Sydney, N.S.W., has decided to separate his engineering department from his ordinary supply business, and has established a branch under the style of the Braulik Engineering Company, 8, Lambeth Hill, Queen Victoria Street, London, E.C. Mr. Eugéne-Brown, M.I.E.E., has now joined Mr. Braulik in the business.

THE WORKINGTON IRON AND STEEL COMPANY, LIMITED, propose installing a mill for the manufacture of steel tyres and axles at their Derwent Works, Workington. The contract for the construction of the mill has been let to Messrs. P. R. Jackson & Company, of the Salford Rolling Mills, Manchester. The company have also determined to modernise the plant in one of the steel rail mills at these works.

MR. F. A. S. ANDREW, who has been associated with the Pyle & Blaina Works, Limited, for the past 20 years, has now joined E. A. Herbert & Company, Limited, Lloyd's House, 6, Lloyd's Avenue, E.C., as a director, and will supervise in particular the department dealing with spiegeleisen, ferro-manganese, ferro-silicon, silico-spiegel, and all other alloys, manganese, manganiferous, iron, and other ores.

THE business of Selig, Sonnenthal & Company has, for family reasons, been formed into a private limited liability company, under the style of the Selson En-

gineering Company, Limited. All the assets and liabilities of the old firm of Selig, Sonnenthal & Company, London, and the Selson Machine Tool Works, Coventry, have been taken over by the new company, and the business will be carried on exactly as before, and under the same management.

In connection with the Certificates of Origin on Invoices for Canada we understand that from February 1 the country of origin in respect of each imported article shall be specified on the margin opposite to such article, or elsewhere on the invoice, when the articles are for entry in Canada under the British Preferential Tariff. A Certificate of Origin is prescribed to be written, printed, or stamped on the face or back of all invoices of articles for entry.

Mr. William Tozer, of 328, Tower Buildings, Water Street, Liverpool, has resigned his position as director and secretary of James H. Tozer & Son, Limited, and the English McKenna Process Company, Limited, both of Birkenhead and London, and has established himself as an iron and steel merchant and railway plant contractor. He has been appointed agent for Liverpool and district and for North Wales for the Shelton Iron and Steel Company, Limited, Stoke-on-Trent.

In this column, last month, we announced that the British Corporation for the Survey and Registry of Shipping, after exhaustive tests, had sanctioned the use of the Thermit process for repairs to fractured sternposts, lower portions of rudder frames, etc., in American ports. We should have stated that the process was sanctioned irrepective of where the repairs are carried out. Their sanction is the result of welds carried out in London, and tested by the Sheffield Testing Works, Limited, and others.

Gilbertson & Company, Limited, of Pontardawe, South Wales, are carrying out extensive improvements at their steel works. The new plant, which will be supplied by Wellman, Seaver & Head, Limited, will consist of one 50-ton basic open-hearth furnace, complete with charging and tapping platforms, valves, chimney, casting pits and producers, also roof and runways for the melting shop, and one overhead type open-hearth charging machine, with auxiliary trolley for handling charging material.

Owing to the increased enquiries for the vertical, high-speed, multi-cylinder gas engines which the Anderston Foundry Company, Limited, have recently put on the market, it has become necessary to open a London office, and in future all London business relating to this department will be dealt with at the office at Queen Anne's Chambers, Westminster, London, S.W. Mr. Frank Adcock, who has been associated with the development of this engine at the company's works since its inception, is in charge of this office.

Notwithstanding the representations made by the British Chamber of Commerce in Paris concerning the prohibitive character of the proposed duty on high speed steel, as well as of the proposal to tax this steel according to the percentage of tungsten or other metal contained, the Chamber of Deputies has adopted the duty of 50 frs. per 100 kilos on steel containing over 2 per cent. tungsten, 4 per cent. chrome, or 1 per cent. molybdenum. In the course of the discussion in the Chamber of Deputies it was stated that steels worth under 50 frs. per 100 kilos would be classed in future as "Ordinary Steel" as at present, if accompanied by a certified invoice.

Brown Bayley's Steelworks, Limited, have just completed the erection of a second Siemens' furnace of a melting capacity of 20 tons. The dimensions of the two furnaces, which embody the latest improvements of the builder, Mr. C. P. Wincott, Sheffield, are 62 ft. by 14 ft., whilst they are of remarkably strong construction, about 250,000 bricks, braced and tied by some 200 tons of steel and iron, being used in the construction of each. The furnaces occupy the Southern extremity of a tract of land which faces the present offices, and is some 13 acres in extent. We understand that further extensions, including the erection of new offices, are likely to be put in hand at an early date.

At a recent meeting of the members of the London Chamber of Commerce interested in raw and manufactured metals, it was resolved to ask the Council of the Chamber to sanction the formation of a Metal Trades Section. An Organisation Committee was formed consisting of the following gentlemen, with power to add to their number:—Mr. J. H. Heap (the British Mining and Metal Company, Limited), Mr. Edw. W. Neems, Mr. Eliot Howard (Hayward-Tyler & Company, Limited), Mr. Pitt Becker (Brandeis, Golschmidt & Company), Mr. W. A. Walber, Mr. John A. Lloyd (A. Lloyd & Sons, Limited), Mr. Jas. Whitby (Geo. Warren & Company), Mr. C. Engholm (Henry R. Merton & Company)."

It is proposed to form a National Industrial Education League, the leading spirit in the movement being Mr. R. Applegarth. Central Offices have already been established at Craig's Court House, Charing Cross, London, S.W. The promoter has already received the approval of no less than 74 trades' councils and of the representatives of industrial workers in upwards of 190 different towns. During many years past much useful work has been done in promoting technical instruction by Government assistance, municipal effort, individual enterprise, and philanthropic help, but experience has proved that while such piecemeal efforts have undoubtedly benefited many, it has left uncared for—and can never reach—the bulk of the children who are destined to become industrial workers.

The twenty-second annual dinner of the "S" Department of Tangyes, Limited, Smethwick, held at the Exchange Restaurant, Birmingham, proved a most interesting and enjoyable social function. About 70, foremen, draughtsmen, and agents were present, and the gathering was presided over by Mr. F. Greenway, in the absence of Mr. J. Robson, who was abroad in the interest of the firm. The toast "Success to the Cornwall Works" was given by Mr. T. Saunders, and supported by Mr. W. Thompson, the head of the general offices. The concert, which succeeded the dinner, was greatly appreciated, being considered the best ever arranged. An interesting presentation took place in the course of the evening, Mr. C. W. Chester, the secretary, being presented with a silver English lever watch as a token of esteem for his services during the past 12 years. The presentation was made by Mr. A. H. Whittle, and was suitably acknowledged.

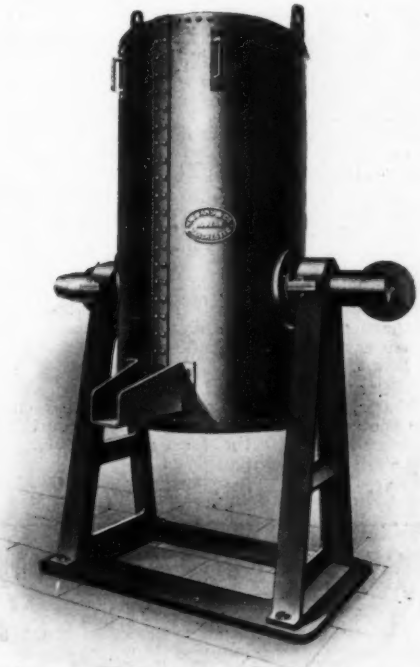
The preliminary prospectus has now been issued of the Naval, Mercantile Marine and General Engineering Exhibition, which will be held at Olympia, London, W., on September 1 to 26 (inclusive). The organising manager is Mr. F. W. Bridges, 119-125, Finsbury Pavement, London, E.C., while the patrons include:—Admiral the Right Hon. Lord Charles Beresford; the Right Hon Lord Glantawe (Past-President, British Iron Trade Association); Sir Nathaniel Barnaby, K.C.B. (Hon. Vice-President, Institution of Naval Architects); Hon. Sir Theodore Doxford (Vice-President, Institution of Naval Architects); Eng. Vice-Admiral Sir J. Durston, K.C.B., R.N., M.I.Mech.E. (Past-President, Institute of Marine Engineers); Sir Douglas Fox, M.I.Mech.E. (Past-President, Institution of Civil Engineers); Sir John Gavey, C.B.; Sir John Jackson, LL.D., F.R.S.E., M.I.Mech.E. (Past-President, Junior Institution of Engineers); Sir Alex. B. W. Kennedy, LL.D., F.R.S. (Past President Institutions of Civil Engineers and Mechanical Engineers); Sir Wm. Thos. Lewis, Bart., (Vice-President Institutions of Mechanical Engineers and of Mining Engineers, Past President Iron and Steel Institute); Sir Guildford Lindsay Molesworth, K.C.I.E., M.I.Mech.E., (Past President Institution of Civil Engineers; Sir Andrew Noble, Bart., K.C.B., F.R.S. (Chairman of Messrs. Sir W. G. Armstrong, Whitworth & Company, Limited; President of the North-East Coast Engineering Trades Employers' Association); Sir Wm. H. Preece, K.C.B., F.R.S., M.I.Mech.E.. (Past President of the Institutions of Civil Engineers and Electrical Engineers); Col. Sir E. Raban, K.C.B., R.E. (Director of Works Admiralty, Past President Junior Institution of Engineers); Sir Aston Webb, R.A., (Vice-President Junior Institution of Engineers); Sir James Williamson, C.B. (Member of Council of Institution Naval Architects; late Director of H.M. Dockyards), and others.

AS SUPPLIED TO THE ADMIRALTY, WAR OFFICE,
COLONIES, AND FOREIGN GOVERNMENTS.

THE Cupola.
Evans's Rapid.

Foundries Completely Furnished.

EVANS'S NEW CUPOLETTE
For Emergency Work.



James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Telegrams: "LADLES, MANCHESTER."

New Companies.

HEPWORTH & GRANDAGE, LIMITED.—Capital £1,500 in £1 shares, to carry on the business of ironfounders, engineers, etc. Registered office: 34a, Aldermanbury, Bradford.

H. C. HARVEY & COMPANY, LIMITED.—Capital £200 in £1 shares, to carry on the business of iron, brass, and general founders, etc. Registered office: 10, Union Passage, Birmingham.

COPE & FRANKS, LIMITED.—Capital £1,000 in £1 shares, to acquire the business carried on by F. W. Cope as Cope Brothers, and to carry on the business of brassfounders, etc.

A. W. MACDONALD, LIMITED.—Capital £12,500 in £1 shares (4,000 preference), to carry on the manufacture of all kinds of machinery. Registered office: 154, St. Vincent Street, Glasgow.

REID BROTHERS, ENGINEERS, LIMITED.—Capital £30,000 in £1 shares, to adopt an agreement with J. Reid and E. J. Reid. Registered office: 12, Wharf Road, City Road, London, E.C.

LEVER, PHILLIPS & COMPANY, LIMITED.—Capital £1,000 in £1 shares, to acquire the business carried on at 6, Parliament Street, Liverpool, by C. Lever, and to carry on the business of ironfounders, etc.

CHATWOOD SAFE, LIMITED.—Capital £80,000 in 4,000 preference shares of £10 each, and 40,000 ordinary shares of £1 each, to acquire the business of Chatwood's Patent Safe and Lock Company, Limited.

BAINBRIDGE ENGINEERING COMPANY, LIMITED.—Capital £2,500 in £1 shares (1,000 preference), to carry on the business of ironfounder, engineer and other machinery. Registered office: 36, Lime Street, E.C.

MERLIN GAS AND ENGINEERING COMPANY, LIMITED.—Capital £1,000 in £1 shares, to carry on the business of manufacturers and suppliers of gas, engineers, founders, etc. Registered office: 22, Parsonage, Manchester.

NORTH BRITISH CRUCIBLE COMPANY, LIMITED.—Capital £5,000 in £1 shares, to carry on in the United Kingdom or elsewhere the business of manufacturers of crucibles, etc. Registered office: 24, Blythswood Square, Glasgow.

NEWCASTLE ALLOY COMPANY, LIMITED.—Capital £8,000 in £1 shares, to acquire the business and assets of the Newcastle Alloy Company, and to carry on the business of manufacturers and dealers in metals and alloys of all kinds, etc.

CLYDE BRASS FOUNDRY COMPANY, LIMITED.—Capital £1,500 in 1,500 ordinary shares of £1 each, to carry on the business of brassfounders and mechanical and electrical engineers. Registered office: 20, West Scotland Street, Glasgow.

COPE & FRANKS LIMITED.—Capital £1,000 in £1 shares, to acquire the business carried on by F. W. Cope as Cope Brothers, and to carry on the business of brass-founders. Registered office: 18, River-street, Balsall Heath, Birmingham.

W. FIRMIN & SON, LIMITED.—Capital £2,000 in £1 shares, to take over the business of a brassfounder and sanitary engineer carried on at St. Stephen's Road, Bow, by W. Firmin. Registered office: 142 and 144, St. Stephen's Road, Bow, E.

WHITE & SONS (OXFORD STREET), LIMITED.—Capital £500 in £1 shares, to carry on the business of ironworkers, brassfounders, etc., and to acquire the workshops department carried on by R. White at 207, Oxford Street, W., as White & Sons.

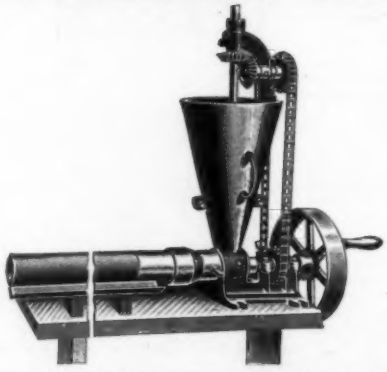
H. J. OXLEY & COMPANY, LIMITED.—Capital £1,000 in £1 shares, to take over the business of steel and file manufacturers and merchants carried on by H. J. Oxley at the Pond Hill Steel Works, Sheffield, and elsewhere, as H. J. Oxley & Company.

ROLLASON & SLATER, LIMITED.—Capital £500 in £1 shares, to acquire the businesses of Rollason & Slater, Limited, carried on at Mitre Works, Richard Street, Birmingham, and at Wombridge, Salop, and to carry on the business of ironmasters, founders, etc.

SELSON ENG. CO., LTD.,

Sole Licensees of the

"RAPID" CORE-MAKING MACHINE.



Makes Round and Oval Cores up to 3 in. Square, Hexagon or Octagon up to 2 in., Irregular shapes up to 3 in.
Makes a Core 18 in. long in about half a minute.
Saves Time and Labour.
Produces Accurate Work without Skilled Labour.

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GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

FIRE CLAY.

Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR, nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

SOUND

STRONG, CLOSE-GRAINED

CASTINGS

Obtained by using

"TITANIUM THERMIT"

TINS READY FOR USE. **ALL SIZES from 2 cwt. to 20 tons.**

Prices and Particulars from

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Telegrams: "FULMEN, LONDON."
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ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Navigation Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

METALS.	End Jan., 1910.	End Jan., 1909.
Iron—Scotch pig warrants ton	*57/9	*54/4½
—Middlesbro' warrants .. ton	51 9	48 7½
—W.C. M/nos Bessemer ... ton	67 0	58 6
—Stock, Scotch ... .. tons	1,000	1,000
Copper—Chili bars, GMB ton	£60 15 0	£58 13/9
—Stock, Europe and afloat tons	110,808	58,681
Tin—English ingots ... ton	£147 0 0	£126 15/0
—Straits ... ... ton	£148 5 0	£124 10/0
—Stock, London, Holland, U.S.A., and afloat ...tons	23,064	21,791
Lead—English pig ... ton	£14 0 0	£13 10 0
Spelter—Ord. Silesian ... ton	£23 7 6	£21 12 6
Quicksilver (75lb)... bottle	£9 10 0	£8 7 6
Antimony—Regulus .. ton	£29 10 0	£32 0/0

* Settlement price.

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (p'ain)	6 10 0	to	6 15 0
Pipes, 1½ to 2½ in.	4 17 6	to	5 2 6
,, 3 to 4 in.	4 10 0	to	5 0 0
,, 5 to 8 in.	4 7 6	to	4 10 0
,, 10 to 16 in.	4 7 6	to	4 10 0
,, 18 to 24 in.	4 7 6	to	4 10 0
Chairs	3 10 0	to	3 12 6
Floor plates (open sand)	3 2 6	to	3 5 0

SCRAP.

The quotations for scrap, subject to market fluctuations. are as follows:—Heavy wrought (mixed), £2 9s. 0d.; light wrought, £1 7s. 6d.; heavy cast, £2 10s. 0d.; all per ton f.o.b., London. Copper (clean). £55 0s. 0d.; brass (clean), £39 0s. 0d.; lead (usual draft). £12 0s. 0d.; tea lead, £12 0s. 0d.; zinc, £19 0s. 0d.; all per ton delivered merchant's yard.

Deaths.

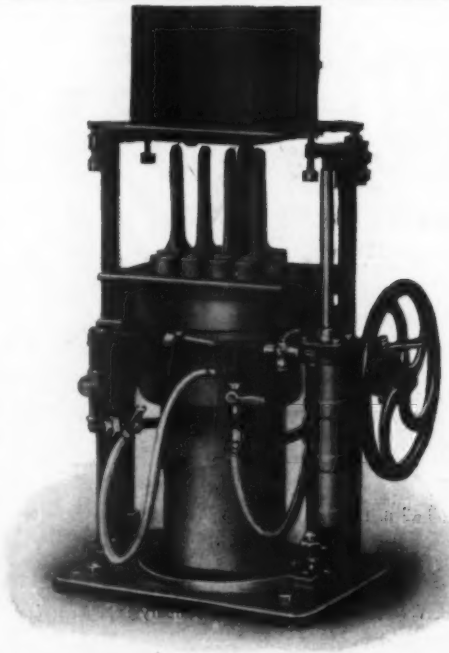
MR. W. J. CUDWORTH, formerly chief engineer at York to the North-Eastern Railway Company, died on December 31, at his residence, The Mount, York.

MR. F. B. SMITH, president of the Crucible Steel Company of America, died unexpectedly on December 30 last, from a stroke of apoplexy. He was 50 years of age.

THE death is announced of Mr. William Johnson, formerly head of the Castleton Foundry, Armley. The deceased gentleman had resided at Scarborough since retiring from the business in Leeds half a dozen years ago.

MR. GEORGE URE, a well-known member of the Falkirk iron trade, died January 3, in his 90th year. The deceased, who was a pioneer in the light-castings industry, retired years ago from the firm of George Ure & Company, Bonnybridge, which was amalgamated with the firm of Smith & Wellstood, Limited, Bonnybridge.

MR. EDWARD RICHARDS, the works manager of the Leeds Steel Works, died somewhat suddenly on January 11, at his residence, Middleton Grange. Mr. Richards, who was 66 years of age, and was born in the South of England, went from the School of Mines in London to the Barrow Hematite Steel Company's Works. There he had various posts of a responsible nature, and went to the Leeds Steel Works in 1890.



"HERMAN"

PNEUMATIC JARRING

MOULDING MACHINE,

BRITISH MANUFACTURE.

This Machine will make perfect deep or shallow moulds in a few seconds.

. NO RAMMING OR PRESSING. .

IN USE ALL OVER THE WORLD.

WRITE FOR PARTICULARS.

PNEUMATIC ENGINEERING APPLIANCES Co., Ltd.,

Palace Chambers, Westminster, LONDON, S.W.

Established 1863.

JAS. DURRANS & SONS,

PHŒNIX WORKS, PENISTONE, Near Sheffield.

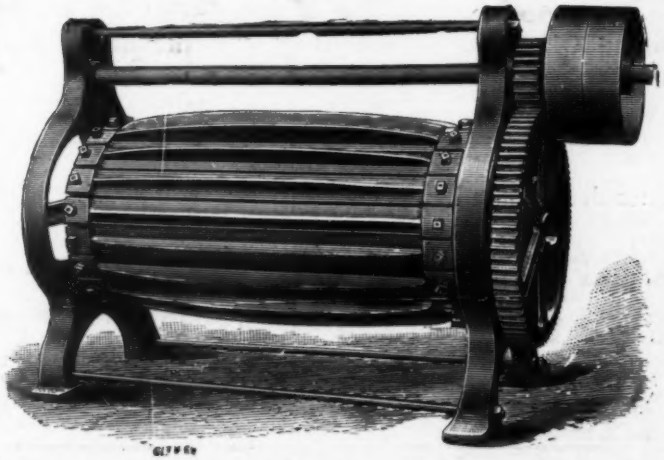
Manufacturers of all

FOUNDRY EQUIPMENTS,

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

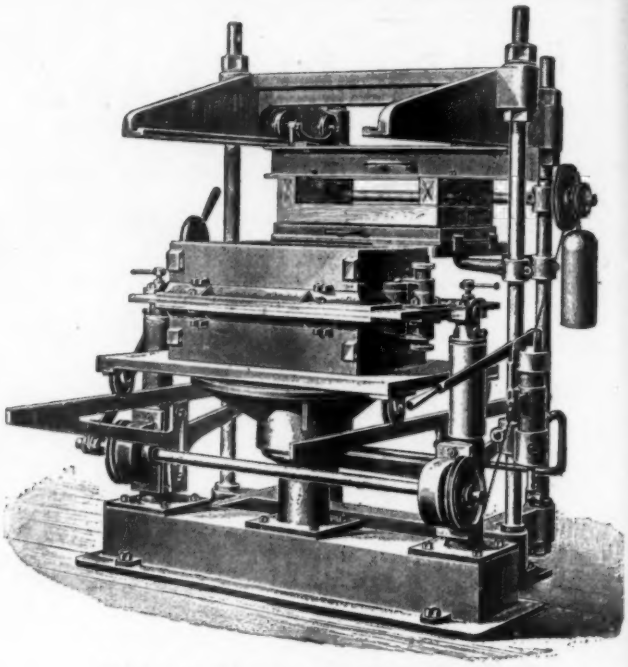
The

Result

OF

Efficiency!

"WE HOPE TO REQUIRE ONE OR TWO MORE."



Hydraulic Turn-over Moulding Machine.
Made in all sizes from 16 in. by 12 in. to 84 in. by 84 in.

Repeat Orders are not given for inefficient machines.

Our machine works and works all the time. No breakdowns

Read what the customers say:

"Replying to your favour of yesterday, the Hydraulic Moulding Machine is working satisfactorily, and we hope later on to require one or two more."

They have since ordered them.

Our Machines deal with a large range of work, will you let us quote you?

Emery Grinding Machines.

Abrasive Wheels.

The London Emery Works Co. PARK, TOTTENHAM, LONDON, N.

THE BUYER'S GUIDE

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Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Steam).
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Marshall & Co., Horace P.
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Air Compressors (Belt).
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Tilghman's Patent Sand Blast Co., Ltd.

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Ash Crushing and Washing Machines.
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Phillips, J. W. & C. J.

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Tilghman's Patent Sand Blast Co., Ltd.

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Pneumatic Engineering Appliances Co., Ltd.
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163	Durrants, Jas., & Sons	Foundry Equipment ...	Penistone, nr. Sheffield	Durrans, Penistone ...	—
114	Dyson, J. & J.	Ground Gannister	Sheffield	Dyson's, Stannington...	702 Sheffield
161	Elders' Navigation Collieries Ltd. ...	Foundry Coke	Cardiff	Elder, Maesteg	10
122	Evans, J., & Co.	Foundry Requisites... ...	Manchester	Ladies, Manchester ...	2297
159	Frodsair Iron & Steel Co., Ltd. ...	Pig-Iron	5, Fenchurch Street, E.C.... ...	Frodair, London ...	—
167116	Goldendale Iron Co., Ltd.	Pig Iron	Tunstall, Stoke-on-Trent	—	—
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114	Hislop, R. & G.	Gas Engineers	Paisley	Gas, Paisley	321 Paisley
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120	Marshall, H. P., & Co.	Core Machines	Leeds	Specialty, Leeds ...	1309 Leeds
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167	Olsen, William	Plumbago and Blacking ...	Cogan Street, Hull	—	—
118	Phillips, Chas. D.	Foundry Core Ovens ...	Newport, Monmouthshire ...	Machinery, Newport ...	18 & P.O. 576
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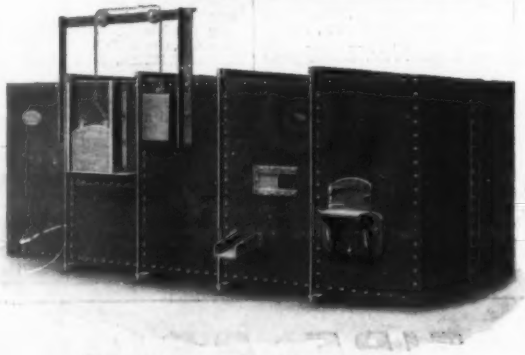

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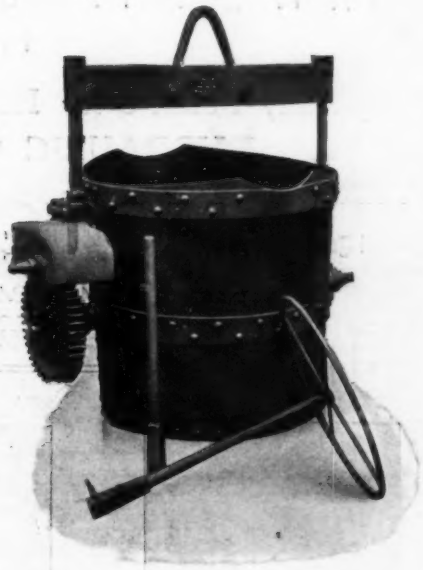

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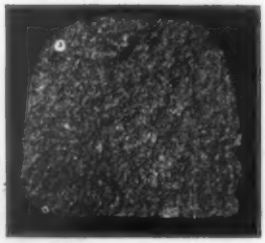

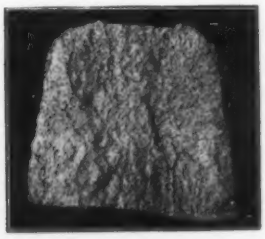

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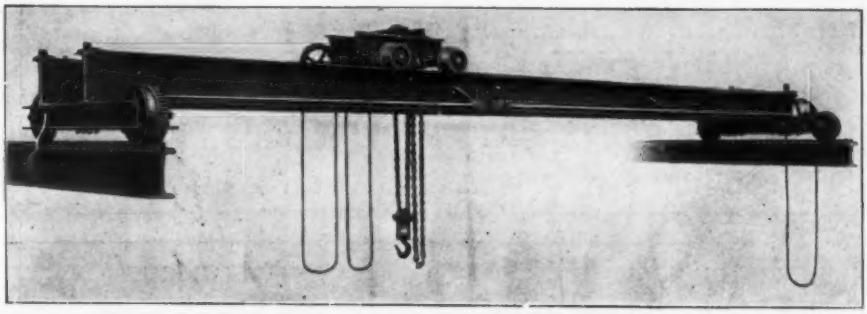

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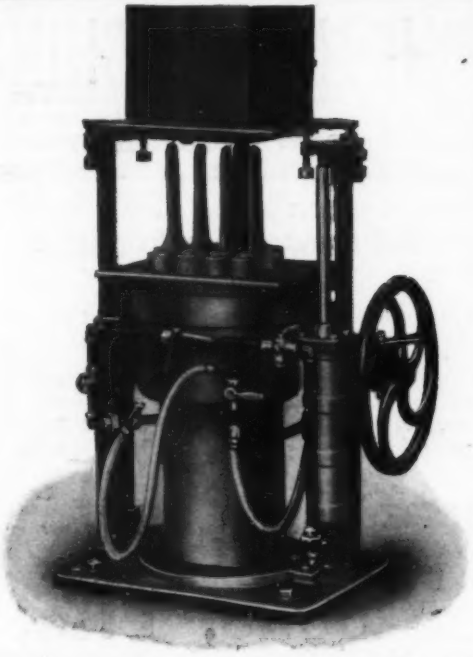

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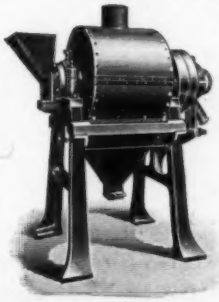

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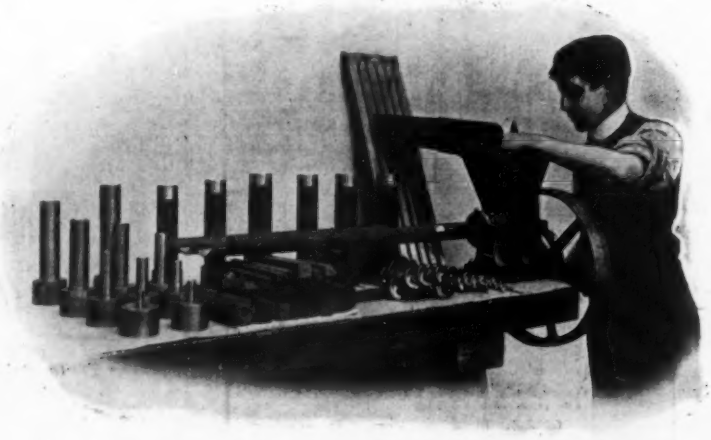

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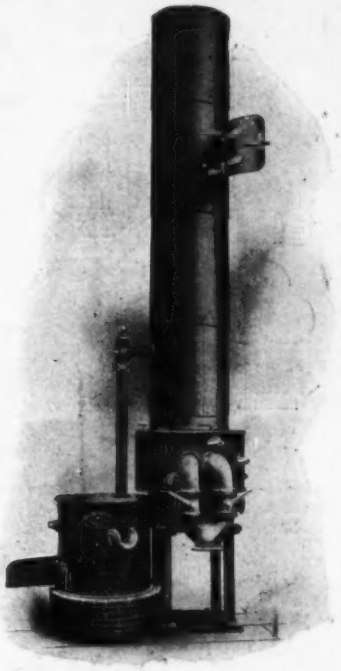

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